SCHOOL OF CIVIL ENGINEERING

INDIANA DEPARTMENT OF HIGHWAYS

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JHRP 86-22

ENGINEERING SOILS MAP OF MARTIN COUNTY, INDIANA
FINAL REPORT

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PURDUE UNIVERSITY

Final Report

ENGINEERING SOILS MAP OF MARTIN COUNTY, INDIANA

TO: H. L. Michael, Director
Joint Highway Research Project

December 10, 1986

Project No: C-36-51B

FROM: Robert D. Miles, Research Engineer
Joint Highway Research Project

File: 1-5-2-80

The attached final report entitled "Engineering Soils Map of Martin County, Indiana" completes a portion of the long-term project concerned with the development of a county engineering soils map of each of the 92 counties of the State of Indiana. This is the 80th report of the series. The report was prepared by Ignatius O. Okonkwo, Research Assistant, Joint Highway Research Project.

Mr. Okonkwo developed the engineering soils map using aerial photographs, available literature, available soil borings and field studies. Generalized soil profiles of the major soils of each landform - parent material area are presented on the engineering soils map attached. The map and report are of value in planning and developing engineered facilities in Martin County.

Sincerely,

Robert D. Miles

Robert D. Miles, P.E.
Research Engineer

RDM/rrp

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ENGINEERING SOILS MAP OF MARTIN COUNTY, INDIANA

by

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Research Assistant

Joint Highway Research Project

Project No.: C-36-51B

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ENGINEERING SOILS MAP OF MARTIN COUNTY, INDIANA

INTRODUCTION

The engineering soils map of Martin County, Indiana, which accompanies this report, was prepared primarily by interpretation of aerial photographs using accepted principles of observation (1). Additional information was obtained from the bedrock geology map of Vincennes Quadrangle (2). The Agricultural Soil Survey Report for the County was used to compile the subsurface profiles indicated on the attached map (3,4). Several field trips were made to classify the soil boundaries that were difficult to establish from the airphotos. Field evidence of the geotechnical problems experienced within the county was also collected during the trips. The aerial photographs were taken in February and July, 1940 for the U.S. Department of Agriculture and have an approximate scale of 1:20,000. The engineering soils map was prepared at a scale of 1:63,360.

Standard symbols developed by the staff of the Airphoto Interpretation Laboratory in the School of Civil Engineering at Purdue University, were used to identify landform - parent material associations and soil textures on the engineering soils map. The text of this report includes a general description of the study area, descriptions of the engineering soil types, and a discussion of the engineering problems associated with the soils and bedrock found in Martin County, Indiana. Appendix A contains boring logs and laboratory test data on specific soil samples.

The predominant agricultural soils associated with each land form - parent material class are discussed in conjunction with the engineering soil types. Information on the engineering properties of these soil series is listed in Appendix B, Appendix C and Appendix D.

Soil boring and profile information was collected and used to develop and verify the soil profiles shown on the map. The profiles were constructed from information in the preliminary Agricultural Soil Survey report for Martin County, from observations of soil profiles along various state and county roads, and from boring logs obtained for roadway and bridge projects within the county.

DESCRIPTION OF THE AREA

GENERAL

Martin County is located in south-central Indiana as shown in Figure 1. A photomosaic of Martin County is shown in Figure 2. Martin County is bounded by Greene County on the north, Lawrence and Orange counties on the east, Dubois County on the south, and Daviess County on the west. The county extends about 26 miles from north to south and about 13 miles from west to east, with an area of approximately 345 square miles (894 sq. km.). The borders are linear except in the southwest corner where the border with Dubois County follows the East Fork White River. Total population according to the 1980 census (5) is 11,001 with 6637 (60 percent) residing in rural areas. Shoals, the county seat, with a population of 967, is near the center of the county and is approximately 85 miles southwest of Indianapolis. Loogootee is the largest city in the county with a population of 3,100. A summary of the population for the county is given in Table 1.

Figure: 1. Location Map of Martin County, Indiana.

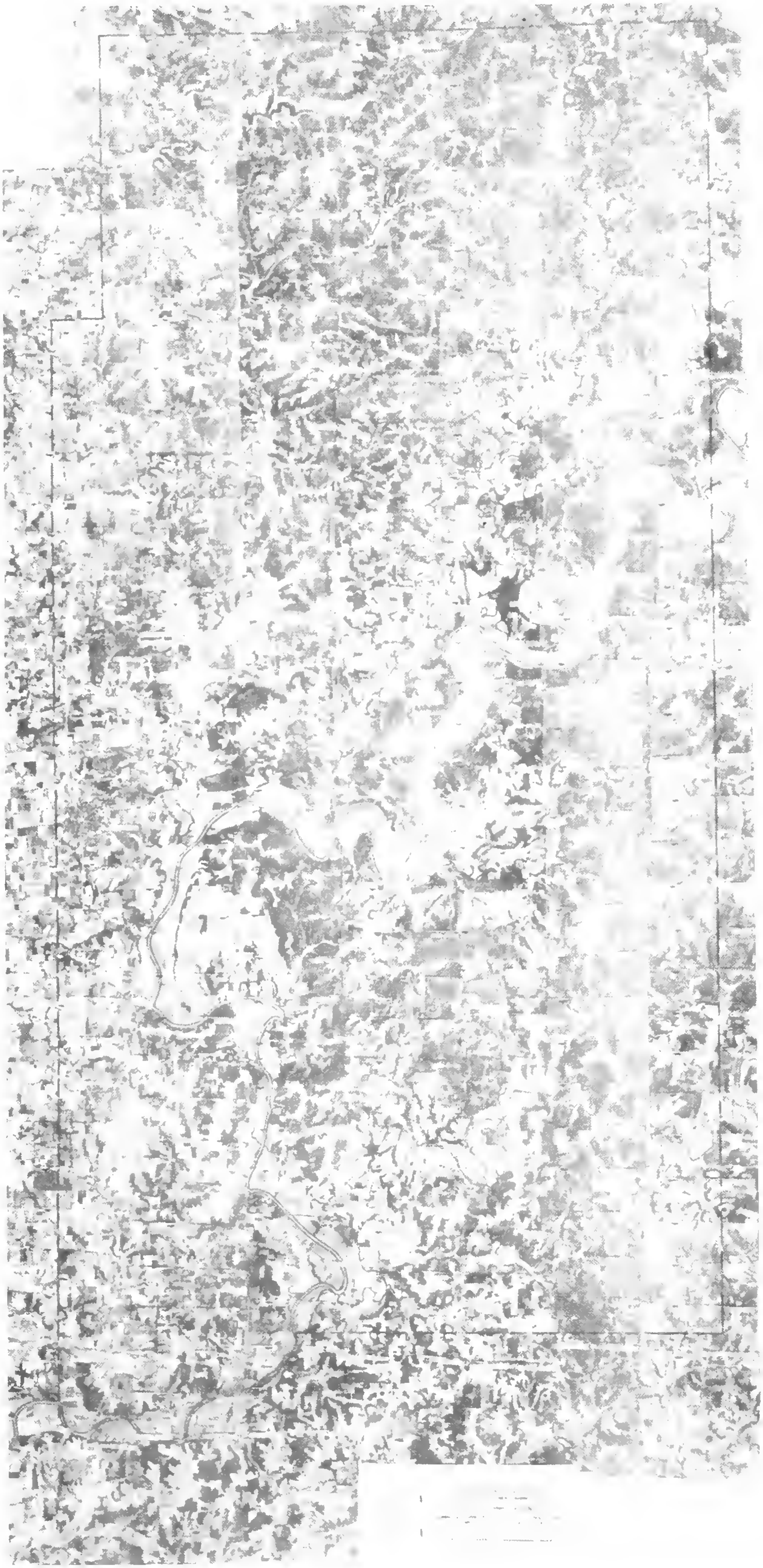


Figure 2. Photomosaic of Martin County, Indiana

Table 1. Population, Martin County (5).

City-Town	Population 1980	1970	Population Difference	Change Percent
Crane	297	339	-42	-12.39
Loogootee	3,100	2,953	147	4.98
Shoals	967	1,039	-72	-6.93
Cities & Towns	4,364	4,331	33	0.76
Rural Areas	6,637	6,638	-1	-0.02
County Total	11,001	10,969	32	0.29

The 1974 U.S. Agricultural Census [6] indicates that about 60 percent of the area is classified as farmland. About half of this percentage is crop land, and a quarter is wooded, and the remainder is in pasture. Approximately 60 percent of the county is under Federal control as national forest or restricted land within the Crane Naval Weapons Support Center which occupies the northern part of the county. The Indiana Department of Natural Resources controls the land in the Martin State Forest for the public benefit. Sandstone quarries, coal mines, and gypsum mines exist in the county and produce building stone and raw materials for other industrial applications.

CLIMATE

The climate of Martin County is characterized by a wide range of temperature between winter and summer. The summers are generally warm and humid, and the winters, though generally mild, frequently have very cold periods of short duration. Sudden changes in the daily temperature particularly in the Spring is not uncommon. Rainfall is well distributed throughout the year. The greatest precipitation occurs in the Spring when the ground becomes saturated. Average annual precipitation is about 43 inches (108.9 cm.). Of this total amount, approximately 23 inches (58.25 cm.), or

53.5 percent, usually falls in April through September [3,11]. Average daily temperature ranges from $31^{o}F$ in January to $76^{o}F$ in July [3]. The expected average seasonal snowfall is 14 inches (35.4 cm.). Average relative humidity in mid-afternoon, during the summer months is about 85 percent.

Other climatological data compiled at Shoals is presented in Table 2 (3).

PHYSIOGRAPHY

The physiographic map of Indiana, as shown in Figure 3, reveals that two subsections are found in Martin County, the Crawford Upland and the Wabash Lowland. With respect to their physiographic situation in the United States, the Crawford Upland portion of the county (about 98 percent of the county area) is in the Interior Low Plateau Province, and the Wabash Lowland portion is in the Till Plains section of the Central Lowland province according to Mallot [7].

The Crawford Upland is characterized by hilly terrain, the surface of which is that of a stream dissected plateau. The hills are marked by distinct highs and lows; ridges, both sharp and rounded; the valleys both v-shaped and u-shaped. In the west-central part, where glaciation occurred in past geologic times, the distinct bedrock topographic forms have been smoothed by glacial deposition. The East Fork White River is deeply entrenched through most of the county. Generally the Crawford Upland, is comprised mostly of interbedded sandstone, siltstone, shale, and limestone. Differential erosion and weakening of the diverse lithologic units in this area is largely responsible for the dissected nature of the plateau and its great diversity in topographic features. Sandstone is prominent near Shoals. Rock benches

Table 2. Climatological Data, Compiled for Shoals, Martin County, Indiana (3)

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year (1914)	Total for the wettest year (1912)	Average snowfall
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	33.3	68	-221	3.56	2.93	1.40	3.1
January	30.8	69	-22	3.74	1.25	3.53	4.7
February	32.5	74	-10	2.53	3.70	3.50	2.7
Winter	32.2	74	-22	9.83	7.88	8.43	10.5
March	42.9	87	2	4.46	2.57	4.83	2.2
April	53.3	90	15	3.67	2.41	6.90	.1
May	63.6	103	29	3.99	.86	10.26	(1)
Spring	53.3	103	2	12.12	5.84	21.99	2.3
June	71.6	106	37	3.94	.88	3.18	0
July	75.8	112	45	3.36	1.44	8.87	0
August	74.0	106	40	4.21	4.45	5.84	0
Summer	73.8	112	37	11.51	6.77	17.89	0
September	67.6	99	26	3.82	2.52	4.41	0
October	55.2	95	16	3.51	2.53	.79	.2
November	43.6	79	-2	2.74	.07	1.33	.5
Fall	55.5	99	-2	10.07	5.12	6.53	.7
Year	53.7	112	-22	43.53	25.61	54.84	13.5

[1] Trace.

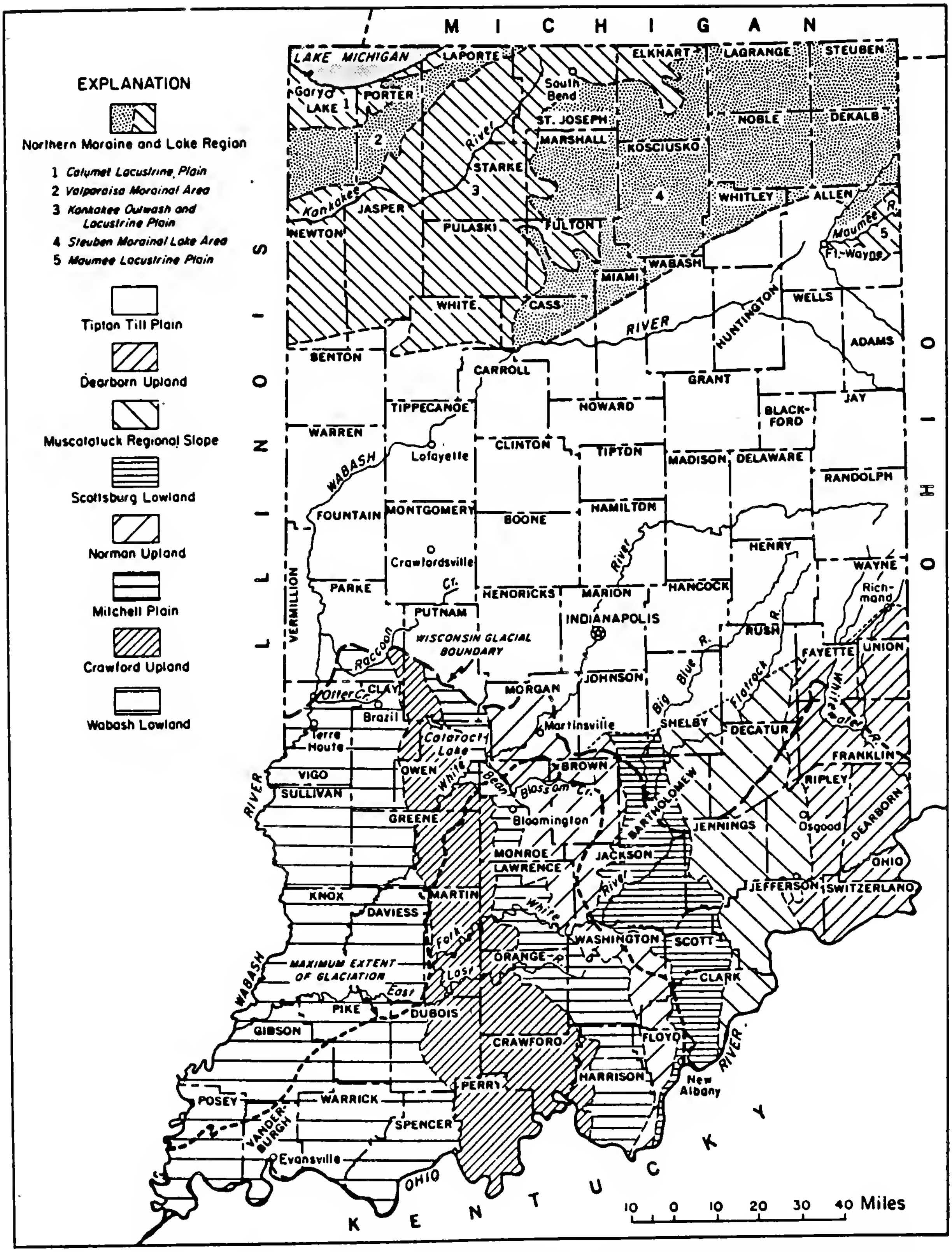


Figure 3. Map of Indiana showing physiographic units and glacial boundaries.

characterize valley slopes in many parts, and valley walls are steep in many other places. A few sinkholes occur in the eastern part of the county. In the western part, ridges appear broad, and valleys are generally wide presumably a result of glaciation. Between Indian Creek and Boggs Creek, in the northeast Central portion of the county, a nearly continuous ridge of the plateau occurs. A highly dissected area characterized by narrow ridges, lies south and east of the East Fork White River. In areas where shale strata are exposed, a step-type topography, resulting from differential weathering, is common. In the East Fork White River valley, isolated hills are common.

DRAINAGE FEATURES

Martin county is characterized by two major drainage watersheds [8]. The extreme southeastern corner of the county, with an area of less than two square miles, is in the Patoka River drainage basin of the state. The remainder of the county drains into the White River drainage basin as illustrated in Figure 4. The central portion of the county is drained by the East Fork White River and its tributaries. The northeastern part drains to White River through First Creek [9]. The drainage map of the county is shown in Figure 5 [9]. The principal river systems of the county are the East Fork White River and the Lost River. Lost River picks up about 67 square miles of watershed within Martin County and has a total watershed of 376 square miles where it joins the East Fork White River [10]. Boggs Creek has a total drainage area within the county of 39 square miles. Indian Creek watershed at its mouth is 172 square miles. East Fork White River drainage area is about 5580 square miles near where it enters Daviess/Dubois County [10].

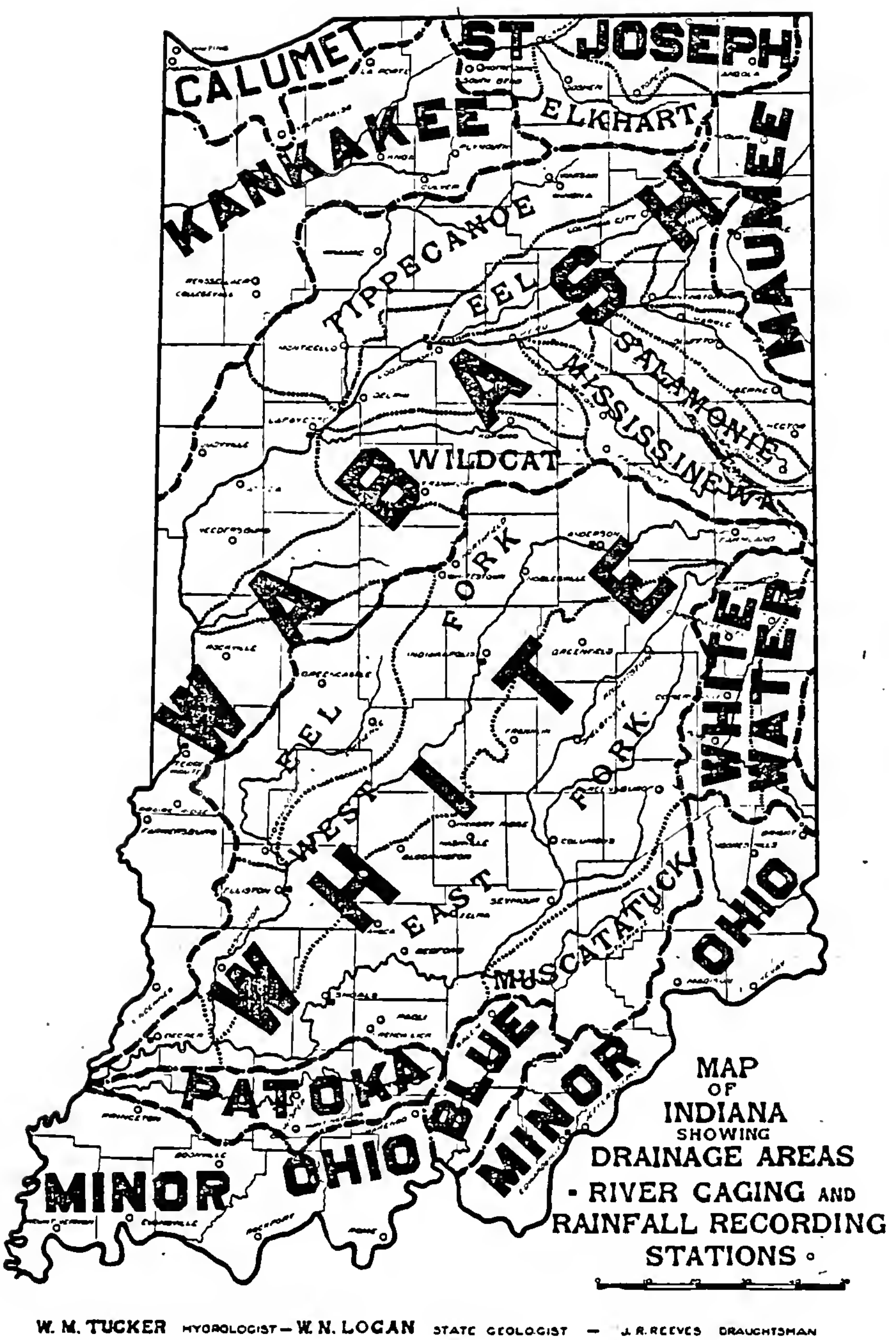
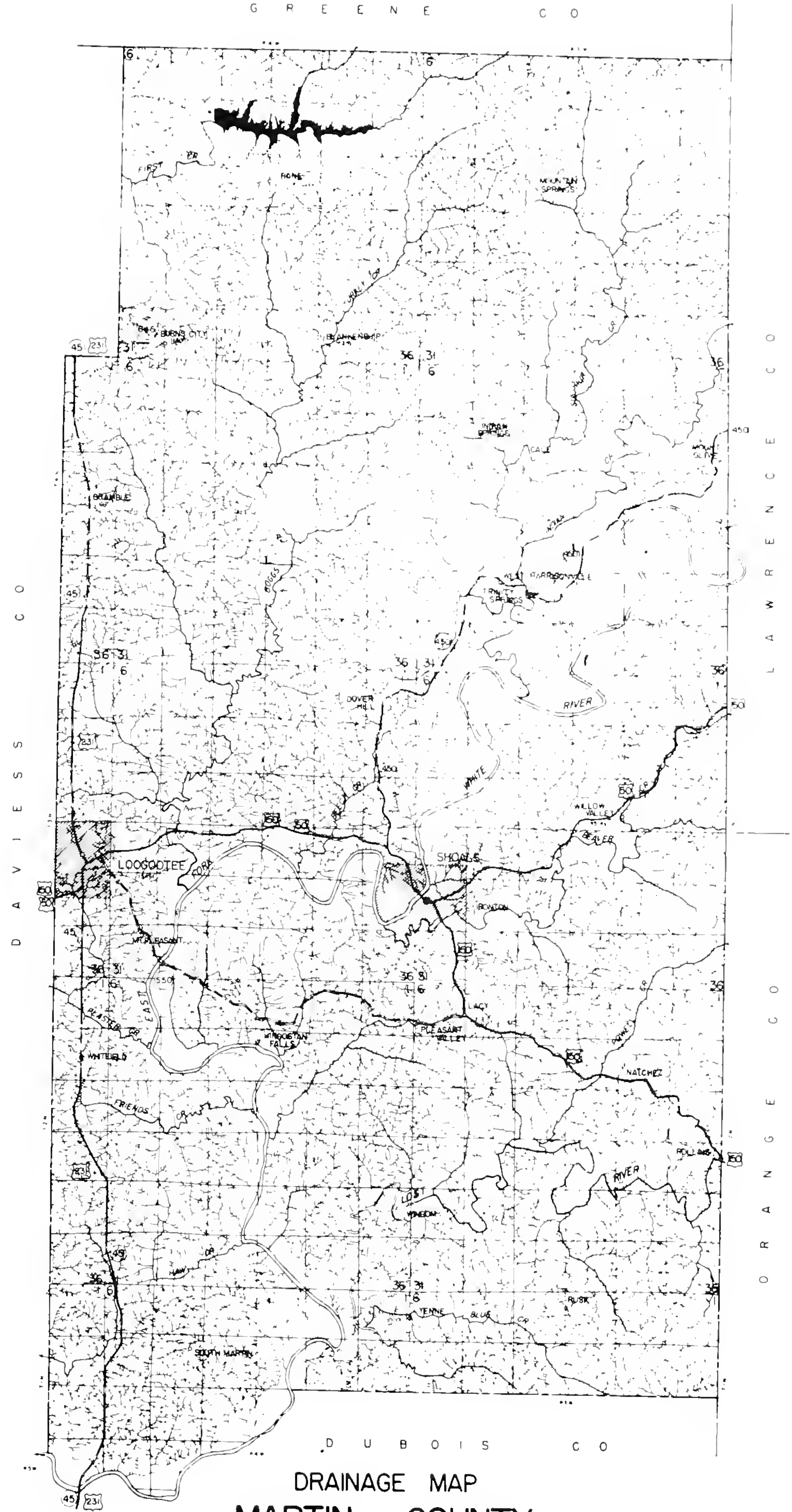


Figure 4. Map of Indiana Showing Drainage Areas and Rainfall Recording Stations.



DRAINAGE MAP

MARTIN COUNTY

INDIANA

Figure 5.

Martin County is dissected by many small streams that empty into either the East Fork White River or the Lost River. The general trend of drainage is to the southwest. Unlike in the neighboring Orange County, the drainage system in Martin County is mostly surficial. The Lost River is exposed in its valley within Martin County.

Drainage is largely controlled by the physiographic setting of the County. The principal streams (East Fork White River and Lost River) are entrenched and meander through narrow channels. In the Crawford Upland section of the county, in the eastern and central parts, the streams are deeply entrenched and the valley form is especially controlled by bedrock. Many of the streams and their distributaries flow on rock in a portion of their courses. The bedrock, in many places, exerts control on the course of the East Fork White River and the Lost River. This is evidenced by the many sharp bends in the valley which occur throughout their length. Indian Creek, in the northeast, and Lost River, in the southeast, are particularly controlled by bedrock. They are both entrenched in rock. In most places, the East Fork White River is gorge-like. In its lower part, south of Loogootee, significant aggregation is observed. The valley varies in width from place to place with significantly wide flood plains.

Beaver Creek, which flows westerly to join the East Fork White River near Shoals, exhibits a significant rectangular course, indicating rock control. A similar control is shown by Indian Creek. At Hindostan Falls in the southwest-central portion of the county, three miles west of Pleasantville, waterfalls exist across ledge rock in the East Fork White River. Sulphur Creek and Indian Creek drain most of the northeastern part of the county and flow south to join the East Fork White River. The northwestern part of the

county is drained by Boggs Creek, Turkey Creek and First Creek, which flow southerly to join the East Fork White River.

Lake Greenwood in the northwestern part of the county is formed by damming First Creek. The dam incorporates a watershed of about 14.8 square miles [10]. Lake Greenwood is the largest lake in Martin County. A few small stock ponds, strip mine lakes, and sloughs within flood plains occur.

In general, the drainage pattern in the upland areas are relatively fine-textured rectangular form due to intensive erosion of the sandstone and shale units. The low order streams exhibit a fine rectangular form, while the high order streams are angular. The East Fork White River acted as a glacial sluiceway. The course of First Creek appears to have been affected by glaciation; as is evident from its southward deflection, near the glacial boundary [9]. Plaster Creek, in its upper reaches, flows nearly parallel to the glacial boundary; its course also appears to have been affected by glaciation. In its lower reaches it flows southeasterly to join the East Fork White River. The southwestern portion of the county is drained by Friends Creek (two miles South of Plaster Creek) and Haw Creek, both of which flow easterly to join the lower reaches of the East Fork White River.

The southeastern portion of the county is largely drained by Lost River and its tributaries. Lost River is fed by Blue Creek, in the south, flowing westerly to join the Lost River, and by Powell Creek in the east, flowing southerly to join the Lost River.

TOPOGRAPHY

Martin County is marked by moderately rolling to extremely rolling to

blocky topography. The western part is characterized by broad ridges, less precipitous slopes, and wide valleys. The eastern and southern parts are highly dissected with many ridges and valleys. Typically, in these sections, the valleys are deep and narrow, and the ridges are sharp and marked by steep slopes. Benches, caused by rock strata that are resistant to erosion, occur in many places between ridgetops and valley floors. Along the eastern border of the county, low basin-like areas pitted with sinkholes are conspicuous. In this area, the underlying Mitchell limestone approaches the surface and outcrops in a few places.

The maximum elevation reported in Martin County is 860 feet (262m) and the minimum is 425 feet (130m) [3]. The elevation at Shoals is 481 feet (147m), at Pinnacle Rock 630 feet (192m), at Brooks Bridge 464 feet (141m), and on a hill a quarter of a mile northwest of Armstrong School the elevation is 790 feet (241m). The topographic map of Martin County is shown in Figure 6 [10].

The East Fork White River is deeply incised 250 to 300 feet (75 to 90 m) through most of the county. The valley is gorge-like in most places. Low, wide, flat flood plains below an elevation of 450 feet (135 m) are associated with the East Fork White River Valley along the southern border, and in the central parts of the county. Areas of low sand dunes are formed along the southern, central, and eastern parts of the East Fork White River flood plain near South Martin, Shoals, and south of Mount Olive. Midway along the eastern border of the county, near Loogootee, are glacial ground moraines and a few lacustrine plains. The ground moraines are generally level summits at an elevation of about 500 to 550 feet (152 to 168m). The lacustrine plains are

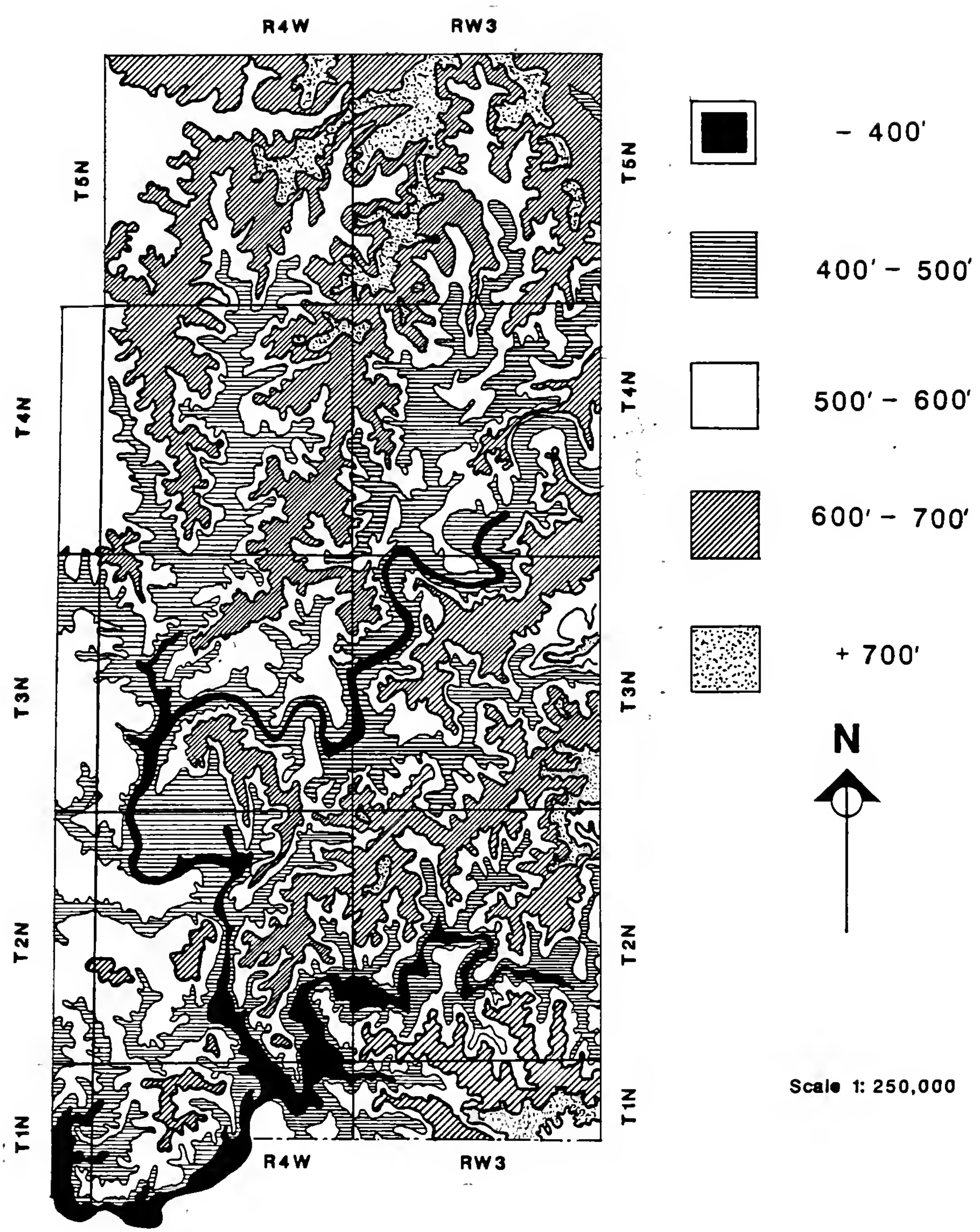


Figure 6. Topographic Map of Martin County. (10)

typically low terraces along flood plains or are low-lying flat surfaces within the ground moraines particularly in the vicinity of Loogootee.

Flood plains are broad and aggraded (filled-in) with alluvial sediments towards the western part of the county. Alluvial stream terraces are common along the East Fork White River. Rock benches are found also within the major river and some minor river valleys. The topographic forms in Martin County, generally are dependent upon the massive sandstones. The massive sandstone in the vicinity of Shoals is about 200 feet (60m) thick and its base is close to the valley level of the East Fork White River. An outstanding denudational remnant of the Mansfield Sandstone in the vicinity of Shoals known as "Jug Rock" is shown in Figure 7 [12]. This is an upright, roughly cylindrical, mass of sandstone rising 40 or 50 feet (12-15m) above its uneven base.

GENERAL GEOLOGY

The surficial geology of Martin County consists predominantly of bedrock of paleozoic age and unconsolidated materials of the Quartenary (Pleistocene) and recent period. Bedrock in the county includes one group of formations of Pennsylvanian age and four groups of formations of Mississippian age [2]. The central and eastern part of the county is underlain by bedrock strata of Mississippian age. Limestone outcrops are common in the eastern part. Whereas, exposures of sandstone abound in the western and central parts. Steep bluffs of sandstone are common. Sandstone in the vicinity of Shoals is massive. Bedrock in the western parts of the county is of Pennsylvanian age. The western part of the county is also characterized by the "Coal Measures" of Pennsylvanian Age. These rocks are more or less non-resistant to weathering processes.

Figure 7. View of "Jug Rock" near Shoals, Martin County, erosional remnant carved from the Mansfield Sandstone. (12)

Most of the unconsolidated sediments are of recent time, but some are of the Illinoian and Wisconsinan times. The recent deposits are comprised mostly of alluvium, but include some colluvial and paludal deposits of the Martinsville Formation [2]. Lacustral and colluvial deposits associated with Illinoian glaciation and identified with the Atherton Formation of Indiana are common along the terraces of the East Fork White River, Indian Creek, and Boggs Creek. Eolian sand dunes associated with the Atherton Formation are common along the terraces of the lower part of the East Fork White River. A ground moraine associated with the Illinoian glaciation and classified as the Jessup Formation [2] is present along the central-western border with Daviess County. Loogootee, near the border with Daviess County, is located in the Till plain. However, portions of this area are covered by lacustrine deposits. No significant geological fault has been mapped in this county. The Mount Carmel fault, a significant geologic structure in southwestern Indiana, is about 22 miles from the eastern part of the county.

BEDROCK GEOLOGY

The areal distribution and type of bedrock in the county is shown in Figure 8 [2]. Also, the columnar section of the rocks in the area is shown in Figure 9 [2]. For clarity, the rock units are grouped into two types, corresponding to the two physiographic subsections found in the county, the Wabash Lowland and the Crawford Upland.

The Wabash Lowland contains the youngest rocks in the county and are mostly series of less resistant rock formation, the soft shales of the "Coal Measures" Formation which are of Pennsylvanian Age.

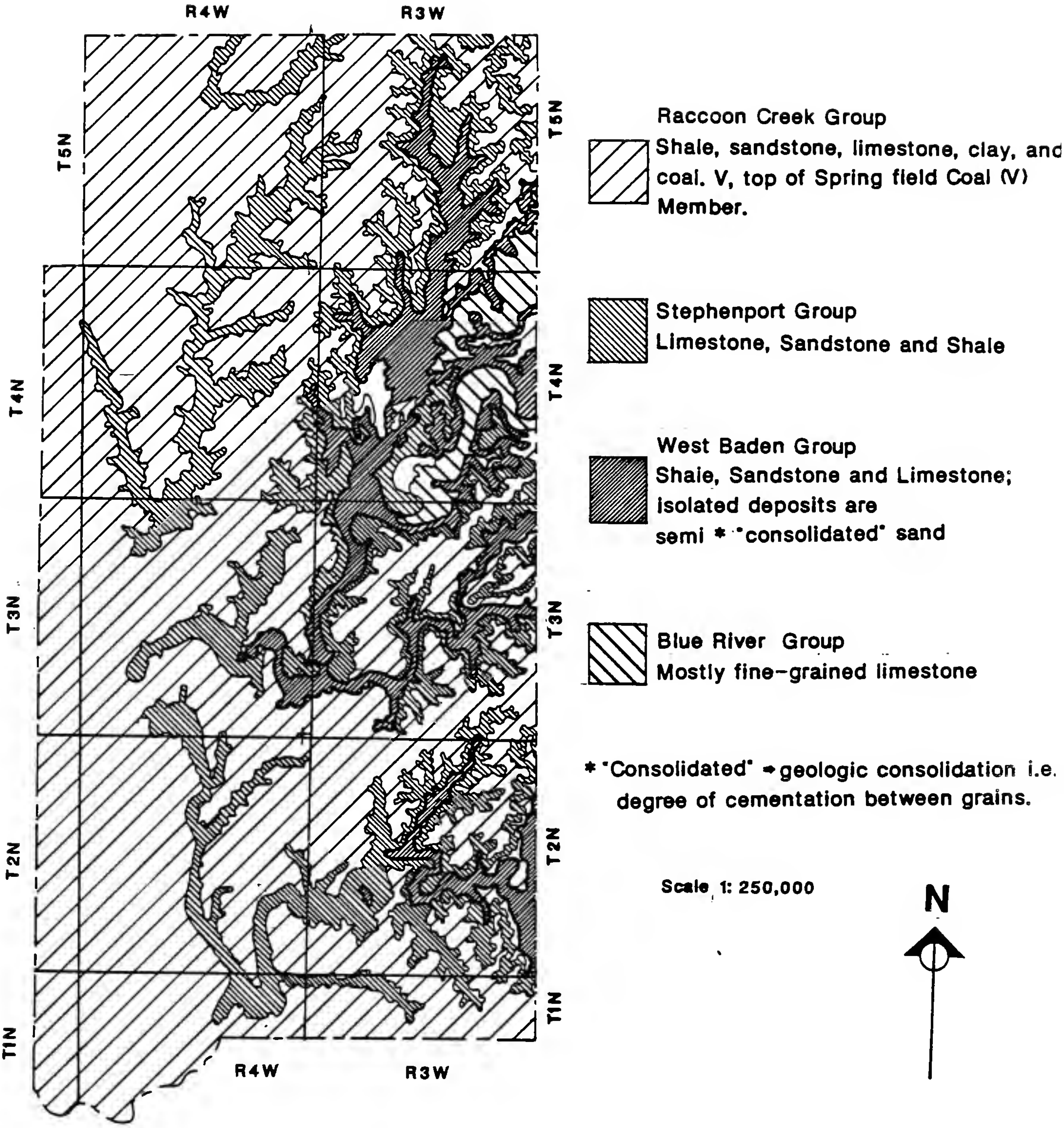


Figure 8. Bedrock Geology Map of Martin County.
(After Reference (2))

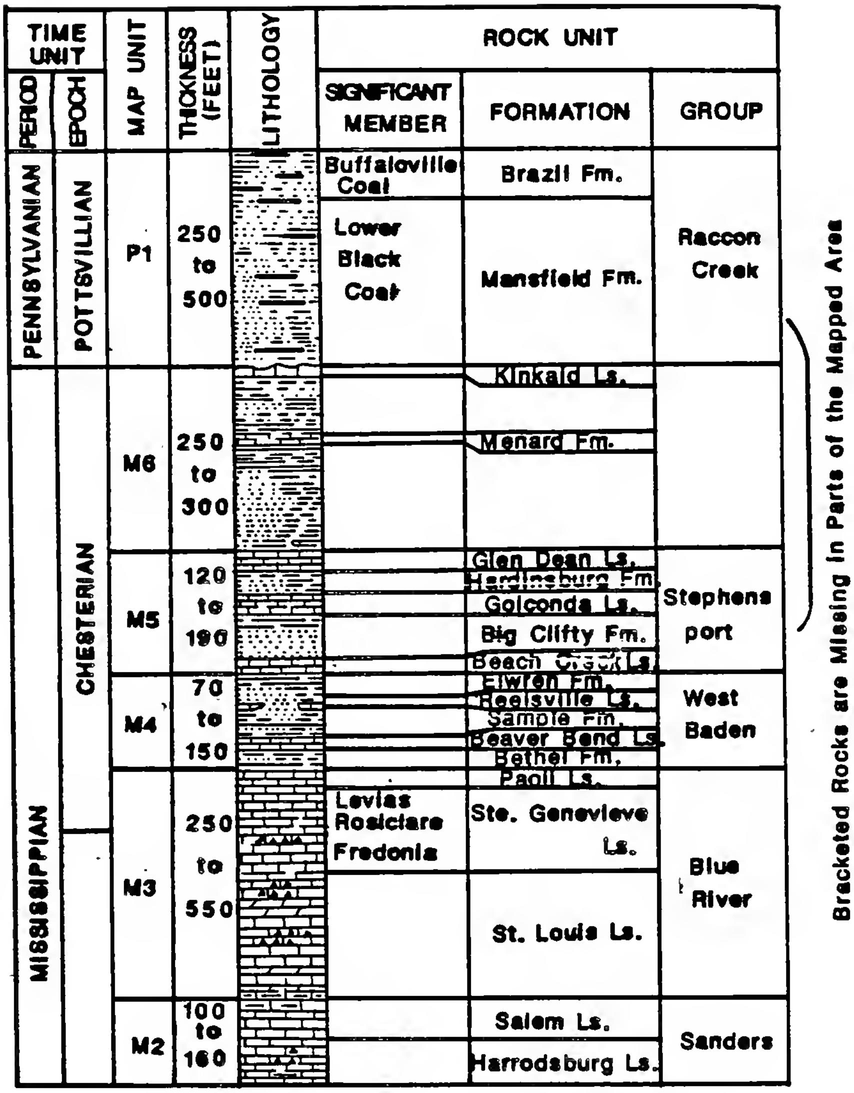


Figure 9. Columnar Section of Bedrock Units in Martin County. (After Reference (2))

The Crawford Upland which occupies a very large part of the county is comprised of a complex system of bedrocks. Both the upper Mississippian and lower Pennsylvanian rocks are present [2]. The Crawford Upland consists mainly of interbedded layers of sandstone, siltstone, shale, and limestone. Rugged, blocky to angular topography results from extensive erosion of the weaker rocks. The oldest members, in the eastern part of the county, are part of the Blue River group and include the Saint Genevieve Limestone Formation. The Blue River group is overlain by the West Baden group.

The limestones in Martin County are characterized by solutioning which results in sinkhole and cavern development. This is common along the eastern side of the county. Where the underlying Mitchell limestone approaches the surface or outcrops, it exhibits a sinkhole relief.

Significant portions of the upper Mississippian rocks are eroded leaving only the rocks of the Late Chester Age in the county. These rocks are mainly composed of varicolored shale, sandstone and limestone of the Menard Formation and the Younger Formation [2]. The rocks are overlain, unconformably by the Mansfield Sandstone of the Raccoon Creek Group of Pennsylvanian Age. These Pennsylvanian rocks are massive and highly jointed. Stratigraphic thickness of these rock range from several feet up to 300 feet (92m) or even more as shown in Figure 9 [2]. In some places, the unit is composed of clay-shale and is much weaker. Table 3 summarizes the description of the bedrock types in Martin County.

PLEISTOCENE GEOLOGY

The unconsolidated deposits of Martin County are shown in Figure 10 [2]. Figure 10 shows only a small area along the western edge of Martin County near

Table 3. Descriptions and Thickness of Bedrock Formation in Martin County (modified from (7)).

Age	Formation	Group	Approximate Thickness (ft.)	General Description
PENNSYLVANIAN	Brazil Formation	Raccoon Creek	4-20	This includes the lower and Upper Coal block of Brazil, and Clay County, Indiana. The ´Block´ Coals are rather hard, jointed, slabby coals, which do not break readily across the laminae. Lower Minshall Coal is overlain by black shale and limestone which are in turn underlain by fine clay.
	Mansfield Formation	Raccoon Creek	a few feet to 280	This is a brownish yellowish, whitish or grey, often pebbly, rather coarse-grained sandstone. Sometimes it is a typical conglomerate, and is often conspicuously cross-bedded and ripple-marked
MISSISSIPPIAN	Kinkaid limestone Menard Formation	—	—	—
	Glen Dean limestone		10-45	Consists of varying properties of limestone and shale and some sandstone. The limestone is bluish-gray, medium, thick bedded and characterized by fossils.
	Hardinsburg Formation		30	Somewhat shaly, fraggy sandstone. The sandstone are ripple marked and very resistant to erosion forming small benches on outcrops.

Table 3. (Con't)

M I S S I S S I P P I A N	Gokonda Limestone		80-120	This is a persistent limestone overlying the Cypress sandstone and Indian Spring shales. Above this is 10 feet of coarsely crystalline fossiliferous limestone, which contains chert.
	Beech Creek Limestone		8-24	Very persistent limestone Formation. On the weathered surface, it presents a ragged face made up of cubical chunks of limestone. It is a gray, compact, to sub-oolitic and often semi-crystalline limestone, frequently locally quite completely oolitic.
	Elwren Formation		40-50	Consists of two masses of sandstone separated by a shale horizon. The sandstone is usually distinctly bedded, but is occasionally massive. The weathered outcrop has a rusty brown color.
	Reelsville Limestone		2-10	A thin limestone of a compact to sub-oolitic oolitic texture. It weathers to a reddish color.
	Sample Formation		30-50	Massive medium coarse-grained siliceous sandstone. It varies notably in lithology and thickness. It is a persistent horizon in Indiana partly shale and partly sandstone.
	Beaver Bend Limestone		10-30	A member of the lower Gasper of Butts. It is highly oolitic, often massive, and conspicuously jointed, forming along its outcrop an important Spring line.
	Bethel Formation	—	—	—

Table 3. (Con´t)

MISSISSIPPIAN	Paoli Limestone			Compact Oolitic limestone forming top of the Mitchell limestone. The rock is a typical Oolitic containing an abundance of shot-like grains with concentric structure. Its color is dark gray to nearly white.
	Ste. Genevieve Limestone and Saint Louis Limestone			Oolitic, and carvenous limestone. Lower St. Louis division is coarse-grained, hard, compact, rather thin-bedded, light dove-colored.
	Salem Limestone		40-100	Oolitic, has high composition of calcium carbonate. Excellent building stone.
	Harrodsburg Limestone		~ 60-70	Oldest and lower most member of the Mississippian Limestones. It is a rather coarse, crystalline, and fossiliferous limestone. It is shaly in some places. Highly calcareous and suitable for use in manufacture of Portland cement.
	Cypress Sandstone		~ 30	Massive, non-bedded or not distinctly bedded, medium to coarse-grained, yellowish to whitish sandstone. Weathers, turning reddish brown, especially along joints. Being massive and strong, it is a cliff-making rock, and has often been mistaken for the Mansfield sandstone. It lacks quartz pebbles which is common in the Mansfield.

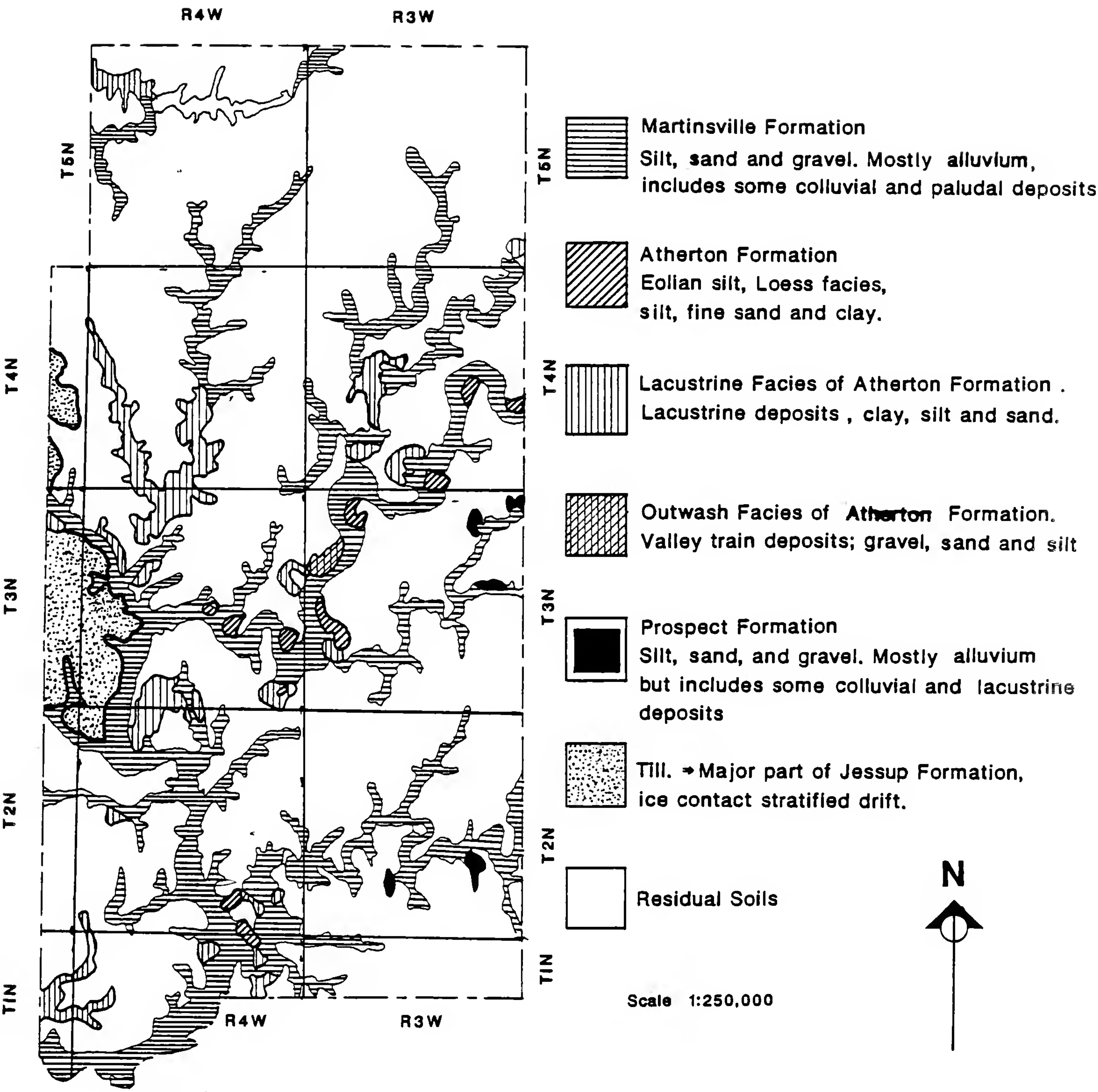


Figure 10. Unconsolidated Deposits of Martin County.
(After Reference (2)

Loogootee affected by Illinoian glaciation. Illinoian drift constitute the surface material except where it is eroded by stream action [2]. The drift is thin in most places, and there appears to be no distinct border. Apparently there is no indication of the existence of terminal moraines.

The East Fork White River acted [9] as a major sluiceway carrying significant volume of meltwater during the Illinoian and Wisconsinan time. The courses of most rivers and their tributaries in the vicinity of the glacial front appear to have been greatly affected. For example, the course of First Creek appears to have been deflected southward near the glacial boundary [9]. Similarly, Plaster Creek, a tributary of the East Fork White River, flows nearly parallel to the glacial boundary in its upper reaches, indicating influence of glaciation. Valley train deposits of Illinoian Age and probably late to early Wisconsinan Age are found along the East Fork White River. As can be inferred from the bedrock topography map of Martin County shown in Figure 11, the thickness of the unconsolidated deposits in the East Fork White River valley is up to 200 feet (60.0 m). The valley train deposits have been eroded in most places, and have been mapped as part of the Outwash Facies of the Atherton Formation [2].

Many slackwater plains and shallow lake deposits are common along most of streams such as the Boggs Creek, Indian Creek and along the East Fork White River sluiceway. These lacustrine type plains are a result of glacial melting when large amounts of debris being carried along the major sluiceway blocked many of the side streams to form lakes. The deposits are characterized by their fine-grained texture. Much of lower Boggs Creek and parts of the East Fork White River near Loogootee consists of lakebed deposits, which are very complex in nature (see map accompanying this report). These deposits

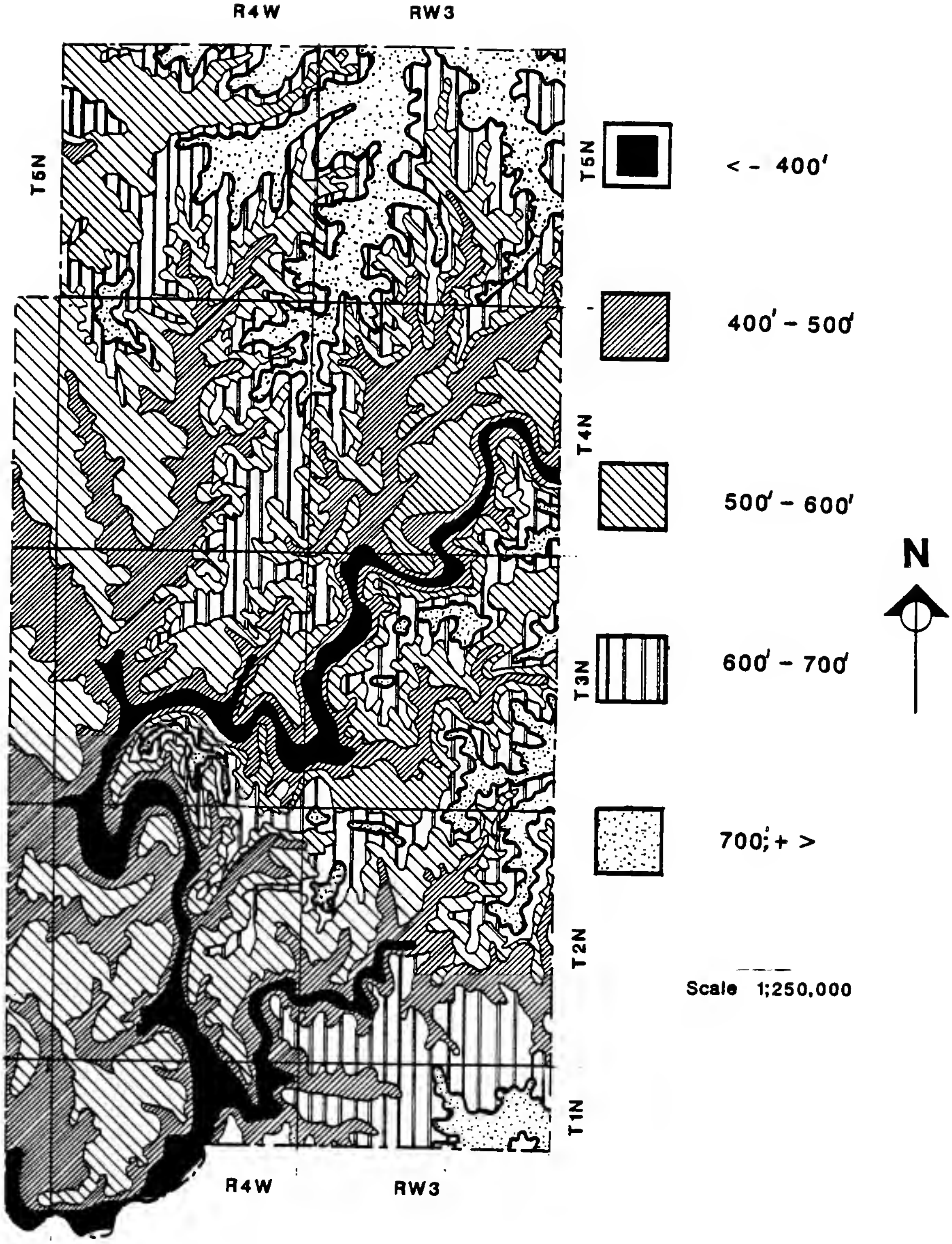


Figure 11. Bedrock Topography Map of Martin County. (13)

represent the Lacustrine Facies of the Atherton Formation.

Eolian processes on flood plains gave rise to the formation of several sand dunes along portions of the East Fork White River. Some of the dunes occur on top of the adjacent benches or the surrounding uplands. The sand dunes occur mostly on terraces along the flood plain and are part of the Dune Facies of the Atherton Formation. A thin layer of loess also was deposited on the uplands. The loess deposits are mostly comprised of fine-grained silt.

The remaining unconsolidated material is mostly alluvial in origin, and includes some colluvial and paludal deposits [2]. These are comprised mostly of silt, sand, and gravels and occur along the major streams in the county and are mapped by geologist as part of the Martinsville Formation.

LANDFORMS AND ENGINEERING SOIL AREAS

The engineering soils in Martin County are derived both from unconsolidated materials and from the weathering of consolidated materials consisting of sandstone, shale and limestone bedrock. The residual soils occur on the uplands as well as along the valley walls. The residual soils in the northeastern and southeastern parts of the county are developed from the interbedded sandstone, siltstone, shale and limestone bedrock of the Crawford Upland. If the limestone bedrock is at the surface the soils tend to be more plastic than the residual soils in the clastic rock areas. In the central and western part of the county, where the soft shales of the Coal Measures Formation cover the Mansfield Sandstone, in the Wabash Lowlands, the residual soils tend to be less plastic. The residual soils also appear to be of less variable thickness, in the Wabash Lowlands.

Generally, the thickness of the residuum in the entire county is highly variable, particularly in the Crawford Upland region. The higher variability of residual soil thickness in the Crawford Upland is attributed to the intensity of dissection, and the rugged nature of the region arising from the differential weathering of the interbedded sandstone-shale and limestone bedrock. Residual soil depth in this region ranges from bare rock exposure on some steep sideslopes up to about 15 feet (4.71m) of soil on the flat ridge tops.

The unconsolidated materials include eolian, lacustrine, glacio-fluvial, and fluvial deposits. Fluvial deposits are confined to the East Fork White River valley and the Lost River Valley and their distributaries and creeks. Lacustrine sediments occur in the former glacial lake site in the northwestern portion of the county (near Lake Greenwood), along First Creek and Boggs Creek, and in the west-central part around the vicinity of Loogootee. Lacustrine deposits also are found in patches along the East Fork White River and the Lost River flood plains, especially at the entrance to tributary valleys. A significant lakebed deposit is found in the lower portion of Boggs Creek valley. Glacio-fluvial material is confined to the East Fork White River and First Creek valleys in the form of valley train remnants, most of which are reworked and almost indistinguishable from the more recent alluvium. Rock defended river terraces occur in many places along the tributaries of the East Fork White River.

Eolian activity in the form of incipient dune development is evident, but limited to the East Fork White River Valley although small areas are found on the adjacent uplands. Loess deposits occur over most of the county.

The deposits of transported materials are not homogeneous and significant variation is expected. General soil profiles showing textural characteristics and properties that are expected for each engineering soil unit are presented on the map accompanying this report.

EOLIAN LAND FORMS

There are extensive eolian (wind) deposits in Martin County (Figure 12, and enclosed engineering soils map). Excluding the alluvial plains, the entire county is covered by windblown silt or loess deposits of varying depths. The eolian deposits are subdivided into two main groups: sand dune and loess plain.

Sand Dunes

The windblown sand deposits in the form of dunes are very limited in Martin County. They are scattered along the East Fork White River bluffs, and (in most cases) assume no distinct dunal form. They are sheets of sand of varying depth overlying terraces, benches and valley walls. They have been geologically mapped as the dune facies of the Atherton Formation.

These landform types are comprised mostly of sand, some include a considerable amount of silt and some clay particles mixed with the sand particularly near the surficial layers [2]. The sands are predominantly fine sand and of uniform size.

On the aerial photographs the surface of the sand dune area appear to have a very coarse texture in contrast to the loess covered areas. Surface drainage virtually is absent in the sand dune area. Interdunal basins are

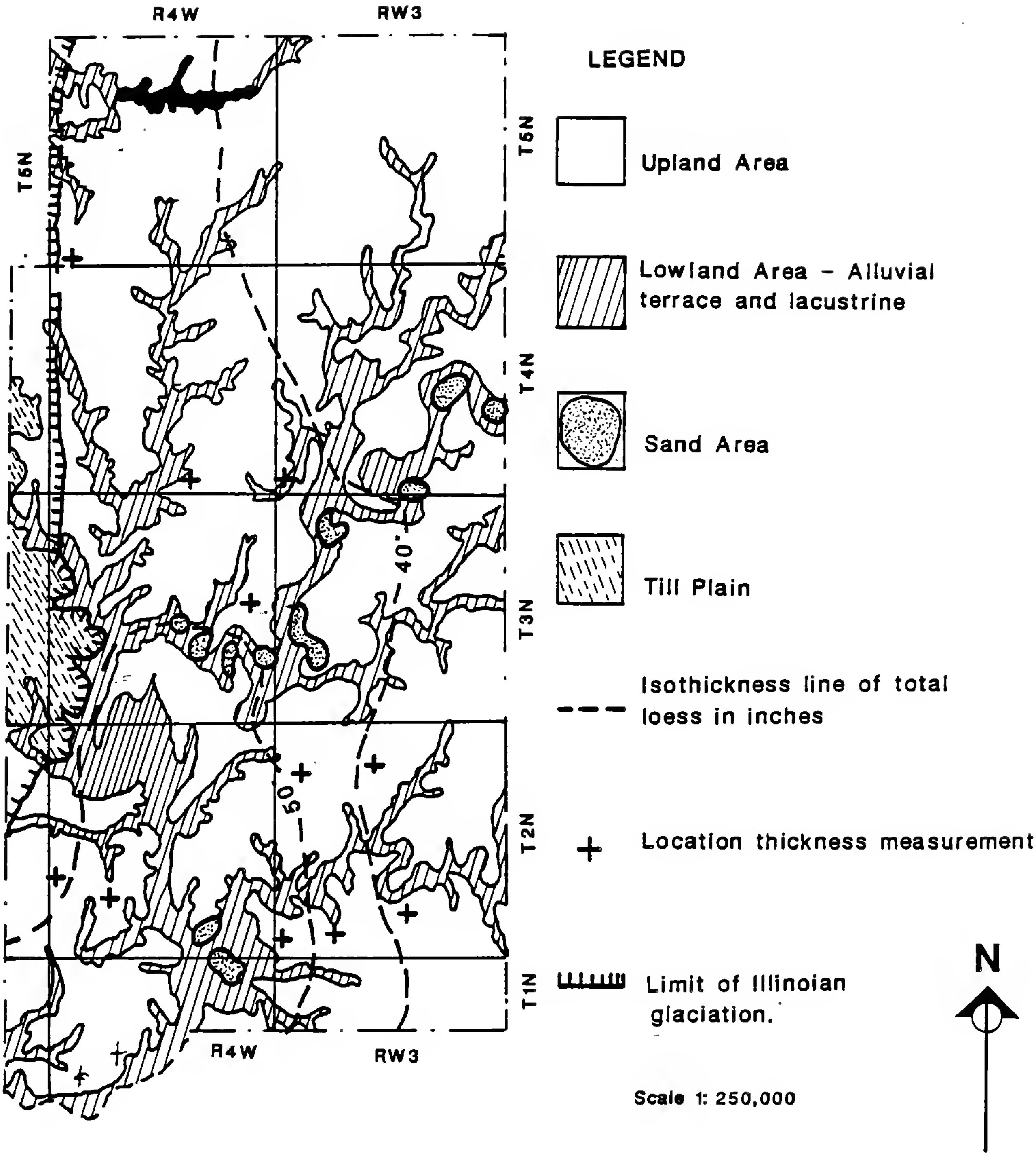


Figure 12. Isopachous Map of Loess Deposit in Martin County. (Modified from (14)

common. Water infiltration in interdunal basins is responsible for the significant dark tonal patterns on the aerial photographs of these areas. The darker areas create a speckled appearance which contrasts with the more uniform gray tone or mohair appearance of the loess covered areas [14].

The soil profile of the eolian drift consists of a loamy fine sand (A-2 soils), fine sand (A-3 soils) or sandy loam (A-4 soils) topsoil, overlying a sandy clay loam to sandy loam (A-4 soils) subsoil.

Engineering problems in this soil region are generally associated with cuts and fills and unstable nature of the sandy material. Because of the proximity of this landform to the floodplain, there is a problem of high water table and erosion by water. These problems call for a study of the characteristics of these materials and those of the underlying materials before any cut is made.

Loess Plain

Extensive wind-blown silt or loess deposits are found in Martin County. Loess covers nearly all the landforms in the county with the thickness of the deposit of over 50 inches (127cm) occurring near the southwest-central part of the county around the valley of the East Fork White River [14]. The loess gradually decreases in depth to less than 40 inches (101.6cm) near the eastern border of the county (see Figure 12 and map accompanying this report).

The loess deposits were blown by westerly winds from the flood plains, terraces, and lacustrine plains. Several studies have indicated, however, that significant deposits of loess in southwestern Indiana were borne by the easterly and southwesterly winds across the western plains and were deposited

during the Wisconsinan glacial period and in recent times (14,15,16). This method of deposition of loess, gives rise to the formation of a loess blanket.

The loess deposits are divided into groups and shown on the map according to the type of underlying materials. The subdivisions are: a) loess on Illinoian ground moraine (b) loess on lacustrine plain, (c) loess on outwash plain, (d) loess on sandstone-shale plateau, and e) loess on bedrock benches.

<u>Loess on Illinoian Ground Moraine</u>

The entire surface of the glacial deposits left by the ancient Illinoian glaciation in the western part of the county is covered by loess. This region exhibits a level but dissected surface. As a whole, the regional slope of this surface is southwesterly. The thickness of the Illinoian drift, in the county, varies from a few feet along the western side of the East Fork White River valley around the vicinity of Loogootee, and increases gradually towards the county border. It is more than 80 feet (24m) deep toward the west in Daviess County. The topography is influenced greatly by the underlying bedrock. The white-fringed gullies characteristic of Illinoian drift are not always present in this region because of land use practices. The loess is thick in this area as it varies from slightly less than 40 inches to over 50 inches (102 to 127 cm). The loess is thin (from 20 to 30 inches (50 to 75 cm)) on slopes near streams and gullies because of sheet and rill erosion.

The soil profile is developed mainly by weathering of the loess and partially the underlying drift material. The surficial soil is a silt loam or silty clay loam (A-4 to A-6) about 7-15 inches (18-38 cm) thick. The subsurface soil contains more clay and is classified as silty clay loam or silty clay (A-7) soil, and occurs at depths of 15-23 inches (38-58 cm). The

C-horizon varies from the loess parent material, when the deposit is thick, to the underlying low-plastic Illinoian clay (A-4 to A-6). This occurs at depth ranges of 23-100 inches (58 - 254 cm). Boring No. 12 along highway U.S. 50, shows that from the surface to a depth of about three feet (1 m), the soil is largely a silty clay loam (A-7-6 to A-4), the topsoil probably has been eroded in this area. The engineering problems associated with this soil type include seepage, erosion on slopes, frost heave and frequent cuts and fills. Landslides or soil slumps resulting from saturated soils on slopes and poor drainage have occurred along US-50 in the vicinity of Shoals.

Loess on Lacustrine Plain

The areas of loess on lacustrine plain are bordered by the area of the Illinoian ground moraine, in the west central part of the county. It is near Loogootee and its immediate environments. It is the transitional zone between the lacustrine plains and the bedrock uplands. The surface is essentially very smooth to slightly undulating. The surface drainage is not well developed. Ditches have been used in several places to facilitate the drainage of surface water. The boundary between this area and the loess on Illinoian ground moraine is marked by the abrupt change in elevation and a change in the topography of the surface. The loess cover in this area is about 45 inches (114 cm). The soil profile is developed mostly in loess.

The predominant agricultural soil series includes the Hosmer and Johnsburg series. In the topographically high areas, the topsoil consists of silt loam or silty clay loam (A-4). In the topographically low areas, the top soil contains more organic material with silt loam or clay (A-4 to A-6). The subsoil or B-horizon contains more clay and is classified as silty clay or

clay (A-6 to A-7). The parent material generally is a silt loam or silty clay loam (A-4 or A-6) soil. A clay layer and/or stratified silty clay loam occur in the deeper portions of the lacustrine deposit.

The major engineering problem associated with these soils is the seasonal high water table. The area is also susceptible to frost heave and ponding.

Loess on Outwash Plain and Terraces

The loess on outwash plains are confined to the northwestern part of Martin County around Lake Greenwood, near Crane. However, some are located on the southwestern side, along the banks of the East Fork White River, about 2 1/2 miles southeast of Mount Pleasant. The largest plain is located north of First Creek and west of Lake Greenwood. The plain is more than 100 feet (35m) higher in elevation than the loess covered lacustrine plain to the south. It is slightly lower in elevation than the loess covered Illinoian drift to the south. Generally, the loess covered outwash plain is dissected severely by erosion of the loess cover.

The predominant agricultural soil series associated with this landform and parent material type include the Negley, Parke and Pike soil series. The Parke soils have 20 to 40 inches (50 to 102 cm) of loess over sandy outwash materials and Pike soils have 40 to 60 inches (102 to 152 cm) of loess over sandy outwash material. The Negley soils have thin loess cover on outwash materials, but in the neighboring Daviess County the underlying outwash deposit is verified by the test boring of the loess deposit by Fahrenbacher [14] at sites Nos. 43 and 44 as reported by Yeh [18]. According to Yeh [18], the red sandy loam Illinoian outwash material is overlain by 70 to 85 inches (178 to 216 cm) of loess at sites located towards the northeastern part of

Daviess County near Martin County.

The soil profile of this area is largely developed from weathering of the windblown loess. The surficial soil or A-horizon is comprised of mainly silt loam which may often contain a little more clay in the low areas and becoming silty clay loam (A-4 to A-6) in the transition zones. The subsoil or B-horizon generally is more clayey and is classified as A-6 or A-7 soil. The parent material is a stratified sand with thin layers of gravel at depth of 12 to 15 feet (4 to 5 m) below the surface.

The engineering problems in this area include the high susceptibility to frost heave, erosion of the loess cover, and frequent cuts and fills.

<u>Loess on Sandstone-Shale Plateau</u>

The loess covered sandstone-shale areas occupy the entire county excluding the areas covered by the lacustrine, glacial, and fluvial deposits. The topography is rugged because of the erosion of the bedrock. The thickness of the loess is about 35 to over 50 inches (89 to over 127 cm) in the interstream areas on the ridge tops. It decreases rapidly on slopes at natural drainageways. At Boring No. 12a (Figure 12, and Table 4) the loess is 60 inches (152 cm) thick on sandstone shale residuum as reported by Fahrenbacher [14].

The soil is partly developed from the loess and, partly by weathering of sandstone and shale. The agricultural soil series that characterizes this area includes the Hosmer, Wellston, Gilpin, and the Zanesville series. The surface soil or A-horizon consists of silt loam or silty clay loam (A-4 to A-6). The subsurface soil or B-horizon is comprised mainly of silty clay loam

Table 4. Loess Thickness Measurements Martin County, Indiana (14)

Location			Total Inches Peo loess	Inches Peo loess	Inches Fdale loess	Underlying Material
T	R	Section				
1N	4W	19,NW40	60	60	None	Ss soil
2N	4W	30,NW160,SW40	45	45	None	Shaley ss soil on ss
3N	5W	36,NW160,NE40	45	45	None	Till on Hv shale soil
2N	3W	9,NW160,NE40	40	40	None	Sh soil
5N	4W	31,SE10	45	45	None	SS
4N	5W	24,NW160,NE40	45	45	None	SS residuum
4N	4W	34,SE160,SW40	50	50	None	Hv sicl sh-ss soil
4N	3W	31,SE160,NW40	45	45	None	Yellow SS
3N	4W	13,SE160,SW10	45	45	10	Sl ss soil
3N	3W	15,SE160	45	45	10 Lland	SS
3N	3W	1,SE160,NE10	40	40	20 Lland	Sl ss soil
1N	4W	17,NE40	55	55	None	SS soil
2N	4W	32,NE160,NW40	50	50	10?	SS soil
2N	4W	4,SE160,NE40	45	45	10?	SS soil
2N	3W	7,SE160,NE40	45	45	None	SS soil
2N	3W	31,SW160,NW40	45	45	None	SS soil

Peo = Peorian

Fdale= Farmdale

to silty clay (A-6 to A-7) soil and the parent material is a silt loam or silty clay loam (A-4 to A-6). Sandstone fragments are found in the deeper layers of the silt loam and silty clay loam soil before the interbedded sandstone-shale is reached at a depth ranging from 48 to 80 inches (122 to 203 cm). Generally, however, a thinner A- and B- horizon may occur because of erosion.

The engineering problems of this area include the need for frequent cut and fills, erosion on side slopes, frost heave susceptibility due to high silt content, and the proximity of bedrock to the ground surface.

GLACIAL LAND FORMS

About one-sixth of the soils of Martin County underlying the loess are of glacial origin. The drift material is of Illinoian Age, but the Wisconsinan Age glaciation produced flood plains, terraces, and lacustrine plains. Due to the extensive loess cover of the county many of the deposits are discussed under the eolian deposited materials. In this section, attention will be focussed upon the soil mainly developed from the glacial materials. The glacial deposit is subdivided into (a) Illinoian Ground Moraine and (b) Outwash Plain.

Illinoian Ground Moraine

The Illinoian Ground Moraine is found in close association with the Loess on Illinoian Ground Moraine. They are located along drainage areas or side slopes in the Wabash Lowland, in the west-central part of the county. Most of the deposits are found in the northwestern part of the county about three and one-half miles north of Loogootee, and some near Bramble City, west of Boggs

Creek. Some are found within and around the vicinity of Loogootee, and extend about three miles to the south of the city. The Illinoian ground moraine is covered by a thin layer of loess about 40 inches (102 cm) thick. The agricultural soil series is Cincinnati.

The parent material upon which the soil is developed is weathered soil that originally was covered by a thin mantle of loess. The surface soil is silt loam which generally ranges in thickness from 7 to 12 inches (18 to 30 cm). This is underlain by a layer of yellowish brown silty-clay loam (A-4 to A-7-6). The parent material is loam or clay loam (A-6 to A-7). The depth to bedrock ranges from 49 to 100 inches (1 to 3 m).

There is a significant variation of strength with depth of the Illinoian Ground Moraine. The initial 1 to 3 feet (weathered loess on Illinoian drift) is typically soft to medium stiff. The upper few feet of the weathered Illinoian drift is moderately stiff. This grades into the medium stiff to hard, loamy, unweathered material. Generally, the Illinoian drift materials are likely to be overconsolidated.

Outwash Plain

Some outwash plains are mapped in Martin County. The largest outwash plain is located just at the northwestern boundary, between Martin and Daviess counties, around the vicinity of Lake Greenwood, and near First Creek. The remaining outwash plains are scattered in the river valleys in the south and central parts near the valley wall of the East Fork White River. Generally, the surface of these outwash plain deposits are not smooth because of the erosion on these landforms. Gullies mark the edges of these landforms where they drop down to the terraces and flood plains.

Most of the outwash plains and outwash terraces are covered by loess. The thickness of loess ranges from 30-35 inches (76 to 90 cm). The agricultural soil series formed on this landform include: Negley, Parke, Pike and Camden series. The typical Camden soil is developed on 1 to 5 percent slopes, in a cultivated field, 2,380 feet south and 2,500 feet east of the northwest corner of section 33, T.4N., R.3W.

Generally the surface soil varies from loam to silty clay loam (A-4), and it is underlain by the subsoil (B-horizon), which ranges from a clay loam to clay (A-6). The soil is developed from parent material, which varies from a sandy clay loam to clay (A-2 to A-6). The substratum is mostly stratified sand with thin layers of gravel at depths of 8 to 17 feet (2 to 5 m).

The engineering problems associated with this landform and parent-material association are connected with intense erosion on the side slopes as well as high frost heave susceptibility.

FLUVIAL LAND FORMS

The fluvial drift in Martin County includes flood plain, terrace, valley train, and lacustrian plain. Significant accumulations of fluvial drift occur along the East Fork White River and its major tributaries. These fluvial drift land forms are often bordered by the higher relief sand terrace deposits; which are subject to incipient dune development. The Lost River valley is also characterized by accumulations of fluvial drift but it is associated with lacustral drift in part of the valley.

Flood Plain

The flood plain of the East Fork White River differs greatly in material

composition from those of the tributary streams. Thus the two flood plain types are separated for discussion. The typical soil profile of the East Fork White River flood plain is more coarse textured in the lower horizons than the alluvium deposited along the tributary streams. This is attributed to the velocities of the glacial melt water which was much higher than that of the present streams. The average thickness of the valley sediments is about 130 feet [17]. The flood plain averages about a half mile (0.8 km) in width, but may be over a mile (1.6 km) wide in sections.

The East Fork White River flood plain is characterized by the following agricultural soil series: Nolin, Newark, Wakeland and Chargin. These soils occur mostly on very shallow slopes of 0 to 3 percent. The surficial soil consists of 7 to 15 inches (18 to 38 cm) of loam and/or silt loam (A-4 and/or A-6), silt loam (A-4, A-6) or silty clay loam (A-4, A-6, A-7). This is underlain by a subsoil which extends to a depth of 3 to 12 feet, and is usually silt loam or silty clay loam. A layer of loam (A-4) or sandy loam (A-2) may be encountered. The third horizon which is loam, is characteristically marked by gravels (< 10 percent). In many places, where the intermediate zone is thin, the third horizon is marked by a layer of stratified loam (A-4) and fine sand (A-2). These soils are generally poorly drained (silty clay loam) to well drained (sandier soils).

Boring No 51 [19] is located along US 50 over East Fork White River in the vicinity of Shoals. Borings 19 to 23 (20) are located along SR 550 about 1 1/2 miles southeast of Loogootee. The subsurface profiles obtained from these borings reveal an upper layer of silt about 6 to 13 feet (1.8 to 3.9 m) thick. This is underlain by another layer of silty loam and sandy loam 8-10

feet (2.4 to 3.0 m) thick. The third horizon is comprised of sand and gravel, which is much shallower along the riverbed. The average thickness of the sand and gravel bed is seven feet (2.1 m).

Flooding is the major problem in this area. Engineering problems related to the soils in this landform type include high compressibility, and low shear strength, thus making the unit generally unsuitable for building sites. Because of the deep deposits of soft materials in the flood plain, design and construction of bridge foundation often present difficult challenges. In general, the flood plain is most suitable for cultivation and for development of recreational facilities.

The flood plain soils formed along the tributaries of the East Fork White River and the Lost River, are treated separately in this report because they are not significantly influenced by glacial meltwater. The tributaries such as First Creek, Boggs Creek, Flat Creek, Turkey Creek in the northwest; Sulphur Creek, Indian Creek in the northeast; Willow Valley Creek, Beaver Creek, Powell Creek in the east; Plaster Creek, Friends Creek in the southwest; and Blue Creek in the south, are marked by narrow alluvial plains. Flooding is anticipated annually in these areas.

The agricultural soil series associated with these flood plains include the Haymond, Stendal, Wilbur, and Burnside series. Slopes are low (0 to 2 percent) along the bottomlands. Generally, the soil profile is moderately uniform and varies between a loam (A-4) or silty clay (A-7) to a silt loam (A-4, A-6). Sandy loam is encountered at a depth of 20 to 50 inches (51 to 127 cm) in some sections. Depth to bedrock ranges from 3 to 6 feet (1 to 2 m) in the Burnside soils formed in the upper portions of stream valleys, but in

general, occur at greater depths downstream. The parent material is the residuum and loess of the surrounding uplands, and are, therefore, usually fine-grained in texture.

Boring No. 40 [21] is located along County Road 60 within the flood plain of Indian Creek in Section 1 of T4N, R3W. The boring data (21) reveals a limestone at a depth of 31 feet (10 m) about 15 feet (4.5 m) away from the stream channel. The soil is predominantly loam, (A-4(0)) or a silty loam (A-6). A subsoil of dense sandy loam (A-2-4 (0)) is encountered at a depth of 20 to 27 feet (6 to 8 m). The bedrock is limestone and occurs at a depth of 30 to 37 feet (10 to 11 m).

Borings 47 to 49 (22) are located in the valley of Indian Creek along S.R. 450, Sections 28, and 29, T4N, R3W. The subsurface profile shown by these borings consists of silty clay loam (A-7) with some fine sand, gravel or clay pockets in the lower horizons. Sandstone and limestone bedrock is at a depth of 70 to 85 feet (21 to 25 m).

The soils in these areas are generally unsuited to building sites because of their high compressibility and low strength, as well as high potential for flooding. Generally, bedrock is not as deep as in the East Fork White River Valley, so less challenge is posed by this soil with respect to bridge design and construction. However, alluvial soils in the wider stream valleys, such as along the lower reach of Indian Creek may be as deep as 80 feet (24 m) (19,22,23). Flood plains are suited only to development of recreational facilities and for cultivation.

<u>Alluvial Terrace</u>

Many terraces are formed in the coarser-grained soil along the lower

portion of the East Fork White River. They are about 5 to 20 feet (2 to 6 cm) above the flood plain. These have been mapped as the dune facies of Atherton Formation in Indiana [2]. Incipient dunes are not uncommon on these terraces. However, the dunes are not in an active stage of migration as vegetation and finer-grained soils cover the coarser sand, and minimizing movement of sand. A small terrace is found in section 5, T3N, R3W; and in sections 17 and 23 T4N, R3W; in Sections 22 and 23, T2N, R4W; in Section 34 T2N, R4W; and in Section 2, T2N, R4W. (See Figure 10 and Engineering Soils Map accompanying this report). Most of these terraces are associated with valley train remnants and, as such, have a large amount of gravel in the subsoil.

The main agricultural soils of this landform-parent material class are the Abscota, Alvin, Chelsea and Martinsville series. All are moderately well drained to well drained, and are gently to moderately sloping. The Alvin and Chelsea soils are found on uplands and sideslopes of terraces. The Martinsville and Abscota are found on terraces above the river bottom and are generally sandier in texture, sometimes containing gravel in the lower sections.

The soil profile generally consists of sand (A-2, A-3), fine sand (A-2), loamy sand (A-2-4) or sandy loam (A-2, A-4) in the upper 20 to 24 inches (51-61 cm). The lower stratum is composed of loam (A-4), sandy loam, loamy sand, and sand. Gravelly sand (A-1) occasionally exist in the lower portion of the profile [4]. Stratified sand and loamy sand is generally encountered below this stratum at a depth of four feet (1.2 m) or more.

Boring No. 11 is located along US 50 between Loogootee and Shoals [17]

(see accompanying soils map). The subsurface profile of this boring reveal three feet (1 m) of silty clay loam material (A-4) as surface soil and an underlying horizon of about 18.5 feet (6 m) of loose sandy loam (A-2-4) with some trace of organic material in the lower 11 feet (3.3 m). This layer is underlain by a layer of brown, wet loose sand (A-2-4) about 5.5 feet (1.67 m) thick. The bedrock in this borehole is a weathered sandstone.

The main engineering problems encountered in this parent material class include: extreme erosion potential, especially along the steep side slopes; high heave potential in the sands; flooding in the spring; and the high water table in the lower terraces. Because of the flooding in this area, building is generally restricted to the higher terraces. Limited farming is done in this area. The land is primarily suited to the development of recreational facilities.

Bedrock-Defended Terrace

Bedrock-defended terraces are small stream terraces located in several of the stream valleys in Martin County, where the underlying rock prevents excessive erosion and maintains the elevated position of this landform above the flood plain. The surface contains a veneer of fluvial drift over the bedrock. Several such terraces are located along the tributaries of the East Fork White River (e.g. in Section 26, T3N, R4W, about one and one-half miles east of Loogootee) and along Indian Creek towards the northeastern border of the county with Lawrence County. The soils are possibly of lacustrine origin, and in some places may have developed from the bedrock. These land forms are separated into bedrock-defended terrace units because of the influence of the rock. Other rock defended terraces are found adjacent to Beach, Willow,

Beaver, Haw, and Blue Creeks. Many rock defended terraces are found throughout the county in minor creeks and streams but are too small to map at a scale of 1:63,360.

The agricultural soil series common in these landform types include the Pekin and the Burnside series. The upper horizon consists of 0 to 24 inches (0 to 61 cm) of silt loam (A-4, A-6), loam (A-4), or silty clay (A-7). The underlying soil (B horizon) extends to a depth of 40 to 60 inches (102 to 152 cm) and is composed primarily of silty loam and silty clay loam (A-4, A-6, A-7). The lower horizon is composed of stratified silty clay loam and sandy loam. Bedrock in this area is usually interbedded sandstone, shale and limestone and occurs at depths as shallow as four feet (1.2 m) close to the valley walls, but rock generally is much deeper at other locations away from the valley walls. No borings are located on any of the mapped rock-defended terraces within the county.

Engineering problems encountered in the soils of these landforms are not numerous. Flooding and erosion is common on the lower terraces. Where dissection of the land is extensive, some cut and fill operation may be required for highway development. The terraces are generally suitable for development particularly where flood potential is minimal.

<u>Lacustrine Plain</u>

About one quarter of the fluvial drift in Martin County is classified as lacustrine plain, slack water plain, or lacustrine terrace. These lacustrine deposits are found along the East Fork White River and its tributaries, and are associated with the Wisconsinan glaciation [2]. These lacustrine land forms are in the form of deep lakebed deposits such as in sections 24, 30 and

36 T3N, R5W and in Section 1, T2N, R5W within and around the vicinity of Loogootee, or as dissected terraces at the entrance to many of the tributary valleys (e.g. Lost River, Boggs Creek, Sulphur Creek, First Creek, and Indian Creek.). A dissected lacustrine terrace overlying limestone bedrock is located in section 36, T5N R3W, at the northeastern border of Martin County. In the remaining part of the county these deposits are underlain by interbedded sandstone-shale. These landforms generally exhibit a very level surface. Gullies are not uncommon, but are often widely spaced, and usually occur along the edge of the plain. The gullies result from sheet wash erosion. The lacustrine plain is recognized on the airphoto by their relatively flat surface and dark tones.

The elevations of the lacustrine plains are generally different because they are associated with different river valleys. The highest one is located at the northwest corner of Martin County with an elevation of 620 feet (188 m) above sea level. Other lacustrine plains or lacustrine terraces reach 500 feet (152 m) around the headwater regions of valleys and about 400 feet (121 m) or more at the outlet near the East Fork White River valley.

The predominant agricultural soil series associated with lacustrine plains are the Bartle and the Henshaw series both of which have shallow slopes and generally appear as bench-like surfaces within valleys. The soil profile generally appears uniform in the upper portion, and is composed of silty clay loam (A-4, A-6, A-7) and silt loam (A-4, A-6). Nevertheless, these deposits become very erratic with depth, particularly where they are bounded by outwash materials. Hence, lenses and pockets of sand, silt and clay as well as thin seams of gravel are interspersed throughout the profile. An illustrative diagram showing the relation of lacustral deposits to glacial outwash is shown

in Figure 13 [24].

Lacustrine Terraces

Lacustrine terraces are generally flat areas typically 10 to 15 feet (3 to 4.5 m) higher than the flood plain. In many places, they occur in close association with outwash plain deposits; however, they are recognized and mapped as part of the lacustrine facies of the Atherton Formation due to the differences in the nature and origin of these landforms. The lacustrine terraces are separated from the lacustrine plains because of their differences in relief and topography. While the lacustrine terraces are restricted to the flood plains, the lacustrine plains occupy a pre-existing upland area. In such places, the lacustrine plain may be broken by widely spaced drainage gullies, and the occurrence of isolated hill remnants of the former uplands are not uncommon, as is the case in and around the city of Loogootee.

As with the lacustrine plain, the lacustrine terraces in Martin County are of different elevations. The low lacustrine terraces are common along the East Fork White River and along Lost River and their tributaries. The higher lacustrine terrace occur along the tributary of First Creek, and along part of West Boggs Creek. The terraces along these creeks could be part of an outwash plain deposit; however, they are the lacustrine facies of the Atherton formation and are mapped as terrace deposits in this report.

Terraces along West Boggs Creek and First Creek are level and are about 40 feet (12 m) higher than the lacustrine plain surface, and about 100 to 120 feet (33 to 36.4 m) below the adjacent sandstone-shale upland. The terrace surface is gently undulating.

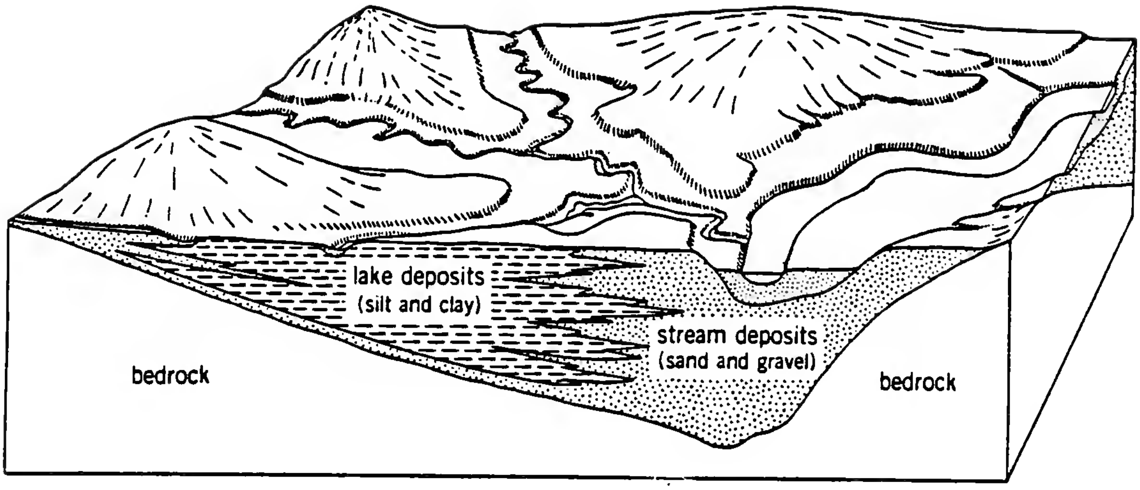


Figure 13. Block diagram showing relationship of lake deposits to tributary valleys, glacial outwash (sand and gravel) and associated stream deposits. (24)

Generally there is very little surface drainage in the high terrace. However, as in the lacustrine plains, short steep gullies are found widely spaced along the terrace face.

The lacustrine terraces generally form a semi-continuous rim around the flood plain. This is very common along the East Fork White River, for example, in Sections 32 and 33, T3N, R4W, about two miles west of Hindostan Falls, and in Sections 5 and 8, T2N, R4W. Another extensive area of lacustrine terrace occurs along the Lost River in Sections 25, 26, 35 and 36, T2N, R4W. Another lacustrine terrace is mapped at the junction of Indian Creek and the East Fork White River, in sections 29, and 32 T4N, R3W, near the city of Trinity Springs.

Three agricultural soils (the Markland, McGary, and Zipp Series) are associated with lacustrine terraces. The McGary and Zipp soils are formed on shallow slopes of 0 to 2 percent, while the Markland is found in the more dissected areas with slope ranges between 2 and 7 percent. The surficial soil (upper horizon) consists of 7 to 17 inches (18 to 43 cm) of silt loam (A-4, A-6) and silty clay loam (A-4, A-6, A-7). An intermediate horizon of silty clay (A-7) extends to a depth of 28 to 31 inches (71 to 79 cm). The lower horizon is composed of stratified silty clay and clay (A-7).

Boring No. 49 is located along S.R. 450 in Indian Creek, near Trinity Springs [22]. The subsurface profile of this boring reveals at least 50 feet (15 m) of silty clay loam, silt, and loam, all classified as A-4 material. Clay and sand seams are present throughout the profile. Gravels are virtually absent. However, sands and gravels may be expected at the boundary between lacustrine and alluvial or outwash plain deposits. Streaks of organic

material are also revealed in this borehole, suggesting that there may have been several episodes of ponding during the formation of the lakebed or slack water landforms.

Most engineering problems encountered in lacustrine sediments are the result of the behavior of contained water and the soft, moist nature of the deposits. The lacustrine material is very porous but relatively impermeable. In most places it is saturated with water. These soils pose difficult foundation problems with respect to buildings because of the low shear strength. This soil is also not suitable for use as a subgrade material because of the high silt content and the soft clays. Highway embankments cause large settlements. Because of the depth to bedrock, construction of bridges is often difficult. Flooding is also a problem in the low-lying areas. In general, lacustrine plains and terraces are best suited to farming and for recreational activities.

BEDROCK LANDFORMS

Most of Martin County is covered by residual soils developed over siltstone, sandstone, shale and limestone, in the form of benches, plains, or plateaus. Soils of limestone origin are found mostly in the karst controlled benches and sideslopes of the Crawford Upland. The limestone bedrock along the eastern part of the county, is an extension of the limestone Mitchell plain of Lawrence County. Shaley and sandy residuum develop over the hills and ridges that make up the plateau of the Crawford Upland. The topography of these areas is characterized by moderate, steep, or very steep slopes. The landform and the parent material type in this area are discussed separately in the following sections.

Sandstone-Shale and Siltstone-Shale Plateaus and Benches

A large part of Martin County is occupied by residual soils derived from interbedded sandstone-shale plateaus or benches. Because of the wide variation and complex nature of the subsurface profiles in this area, the unit is divided into three parts: soils associated with interbedded sandstone-shale over limestone plateaus; soils associated with sandstone-shale plateaus; and soils associated with the sideslopes of the dissected plateaus. Soil texture, depth to bedrock, and erosion characteristics are completely different for the three groups.

Sandstone-Shale Over Limestone Plateaus

At several locations throughout the Crawford Upland, a complex geology of interbedded sandstone, shale, and limestone produces a residual soil cover which is very different from that where the parent material is predominantly sandstone-shale. This is mostly found along the lower slopes where the interbedded sandstones, shales, and limestone of the West Baden Group overlie the thicker limestone rocks of the Blue River Group. The sandstone-shale over limestone residuum is found at a depth of 4 to 20 feet (1 to 6 m), or more, with the shallower soils located on the ridge tops and upper sideslopes and the deeper soils found on the lower sideslopes. Rock fragments occur throughout the soil profile. Groundwater is noted at a depth of 16 feet (5 m) in boring No. 24 (25) and at 28 feet (8.4 m) in boring No. 25 (25) (See Appendix A) along U.S. 50 from Shoals to Huron, Indiana [25].

Several borings are located along SR 450 further away from Indian Creek flood plain in Sections 26 and 27, T4N, R3W; in the eastern part of the county [22]. The route is through a very rugged terrain, and depth to bedrock is

highly variable. The soils revealed by the borings in this location, are predominantly silty clays (A-6, A-7-6) and clays (A-7-6) and silty clay loam (A-4, A-6). The composition of the residuum reveals the complex nature of this part of the Crawford Upland. The soil profile, typically consists of mostly silty clay (A-6) and silty clay loam (A-4, A-6) in the upper horizon, and about 1 to 4 feet (0.3 to 1.2 m) deep. The intermediate horizon consists of stiff brown clay with fragments of highly weathered shale with traces of sandstone, about 3 to 5 feet (1 to 1.5 m) deep. The lower portion is composed of either shale, sandstone or limestone bedrock.

Numerous engineering problems are encountered in the interbedded sandstone, shale and limestone areas. The complex geology, and variable depth to bedrock pose problems in planning cut and fill requirements for highways. Due to the varying parent material types and their soil associations, slope instability is common along highway cuts. The shaley soils present a unique challenge when used as fill in an embankment. Problems of slaking of the shale and difficulty in compaction arise when they are used as fill. These problems require that special procedures be employed when shale is used as a construction material [26,38]. Solution features, commonly sinkholes, develop where limestone is close to or at the surface as in Sections 35 and 36, T5N, R3W, and Sections 1, 2, 11 and 12, T4N, R3W, in the the eastern part of the county.

The clayey soils are generally poorly drained and as such cause drainage problems. The highly rugged topography makes a large portion of the area inaccessible. This situation, therefore, requires that development be restricted to the broader drainage divides and ridgetops.

Sandstone-Shale Plateaus

Residual soils developed on sandstone-shale plateaus are of greater thickness than in the adjoining more steeply sloping areas. These soils generally are derived from clastic parent rock and are common on the ridges and flat uplands of the highly dissected sandstone-shale plateau. A loess veneer less than 60 inches (152 cm) thick covers the residuum throughout the unit. The agricultural soils formed in these areas include the Ebal, Gilpin, Hosmer, Wellston and Zanesville Series. Ebal soils are formed on the flatter portions of the plateau, with slopes ranging from 0 to 18 percent. The residuum is 5 feet (1.5 m) or more in thickness [4]. A topsoil of silty loam (A-4), 8 to 10 inches (20 to 25 cm) thick, overlies 10 to 19 inches (25 to 48 cm) of silty clay loam (A-4, A-6, A-7), silt loam, or silty clay (A-7). The substratum is composed of either clay (A-7), or a silt loam that may be a fragipan. The Gilpin and Wellston soils are found on the upper portions of the valley sideslopes (0 to 75 percent). Here the soil mantle is thinner and contains a higher percentage of rock fragments than the Ebal and Hosmer Series. The Gilpin soils generally are composed of silt loam to very shaley, silty-clay loam containing up to 30 percent rock fragments greater than three inches (7.6 cm) in size, and are classified as A-1, A-2, A-4, or A-6. Wellston soils show about 25 inches (64 cm) of silt loam (A-4) or silty clay loam (A-4, A-6, A-7), underlain by shaley to very shaley loam to a depth of 50 inches (127 cm) or more where bedrock is encountered.

The upland residual soils are moderately plastic. Ebal soils have plasticity index ranging from 5 to 30 with a liquid limit range of about 25 to 55. Gilpin soil plasticity index ranges from 4 to 15 with a liquid limit range of 20 to 40. The Wellston soils plasticity index is 5 to 20 with a

liquid limit range of 25 to 40 [4]. The Zanesville soils plasticity index is 2 to 20 with a liquid limit range of 20 to 40 [4]. In general, the soils are fairly impermeable and, thus, marked by low infiltration rate and high runoff. The upland residual soils are of moderate to low bearing capacity (4, 17, 25), and are moderately compressible. Sound bedrock occurs at depths less than 10 feet (3 m) (See Appendix A). Because of the silt content of this soil unit, frost heave potential is very high and is greatest where the loess blanket is thicker. Pumping is a common problem in compacted fills for roadways. Piping also is a problem in places where silty soils are used for constructing farm or residential water retaining embankments.

Sandstone - Shale Plateau Sideslopes

Soils developed over sandstone-shale sideslopes are common on the steep sloping hills of the Crawford Upland and on hills in the Wabash Lowland. The soils developed on the steeper portions of the valley sideslopes generally are shallow and contain more rock fragments than those of the adjacent uplands. Large fragments of shale, siltstone, and sandstone are common.

The predominant agricultural soils include the Gilpin and the Wellston series, formed on slopes up to 50 percent and more. In areas where the residuum is fully developed, the near surface soil consists of 10 to 12 inches (25 to 30 cm) of silt loam (A-4) or channery (stony) silt loam (A-2, A-4). The subsoil consists of very channery silt loam interspersed with loam (A-2, A-4). Rock fragments greater than three inches (7 cm) in size comprise up to 35 percent of the soil. Bedrock is at a depth of 20 feet (50.8 m) or more.

The engineering properties are similar to those described for the cohesive soils found in the level upland soils. The soil is moderately

plastic with moderate shear strength [4,25]. Engineering problems encountered here are similar to those for the level upland soils. Additional engineering problems encountered include high surface runoff and consequent erosion and slope instabilities.

<u>Benches in Sandstone - Shale Plateau</u>

Benches composed mainly of limestone interlayered with sandstone in the sandstone-shale plateau are present along the valley walls of major stream and creeks particularly in the central and eastern part of the county. Rock benches are common along the East Fork White River, Beech Creek, Indian Creek, and Lost River, and their tributaries. They are located 15 to 50 feet (4 to 15 m) above the flood plains and are fairly flat surface with steep sideslopes towards the valley.

Two significant rock benches developed on Mansfield sandstone ledges are mapped on either side of Beech Creek in Sections 1 and 12, T3N, R3W south of Dover Hill. At one or two places on this bench, sinkholes occur due to the presence of the underlying Glen Dean limestone. A second and more prominent sandstone bench occurs on the Cypress sandstone along Flat Creek in Section 31, T4N, R3W, north of Dover Hill. Because of the small scale at which the map accompanying this report is prepared, it is not possible to show all the areas of rock benches on the map.

The predominant agricultural soils include the Crider, Gilpin and Wellston series. These are developed on a thin veneer of loess overlying soils developed from the underlying bedrock.

The soils developed over bedrock benches in the sandstone-shale plateau,

are generally cohesive and moderately well-drained. Liquid limits for the soils range from 20 to 40 with plasticity index of 4 to 15 [4]. The surface soil is silty and is less plastic than the subsoils. The soils generally have low to moderate bearing strength. Pumping, frost heave potential, and piping are problems associated with these soils as a result of high silt content. The soils developed on rock benches are poorly drained internally, and erosion is severe [24]. The water table in these soils is seasonably quite high.

Limestone Benches

Soils which form on limestone benches are primarily on the eastern side near the border of the county. Unlike the soils developed over the sandstone shale in the central and western part of the county, this soil covers a very small portion of the total area in Martin County. It occurs along steep slopes of valleys, and as bedrock benches along streams, where they are often capped with alluvial materials. Benchlike limestone outcrops are occasionally found on the hillsides.

The agricultural soil series developed on the limestone bedrock include: Fredrick silt loam, and the Corydon silt clay loam. Both the slope phase and eroded phases of the Fredrick silt loam are mapped in these areas.

The Fredrick silt loam occurs in a number of small areas near the eastern border of the county where the Mitchell Limestone and the various limestone formation of the Chester rock series have been exposed. The major areas are in the valley of Indian Creek and near Powell Valley School. The average thickness of this soil is 10 inches (25.4 cm). It consists of friable, smooth, light brown to grayish brown silt loam (A-4) that changes abruptly to friable crumbly yellowish-brown silty clay loam. This gradually merges with a more

compact, tough heavy silty clay (A-7) below a depth of 18 inches. At a depth of about 30 inches the subsoil is brownish-red, waxy, tough plastic clay containing some chert fragments. Sinkholes are numerous in some places. Sinkhole development appears to be greater in locations where the soil is derived from the Mitchell Limestone formations. The soils derived from the various limestone formation of the Chester series have been known to be free of chert [3], but often contain abundant siliceous fossils.

Variable depth to bedrock and thinner mantle are the main characteristic features of residual soils developed on limestone benches. Gully erosion is not uncommon in this unit. The agricultural soil series found on the limestone benches of Martin County include the Corydon and Fredrick soils. They develop on slopes of more than 40 percent. They are formed from the relatively pure limestone of the Chester rock series and from the cherty Mitchell Limestone, where they outcrop on the steep hillsides along the eastern border of the county, principally in the valley of Indian Creek and the East Fork White River. The surface soil consists of 10 to 14 inches (25 to 36 cm) of dark brown silty clay loam (A-7). The subsoil consists of yellowish-brown or light reddish-brown silty clay with some rock usually embedded in the soil mass. Limestone bedrock occurs at depths of 18 to 36 inches (45.72 to 91.44 cm). Bedrock depths are generally shallow. Thin soils occur on the upper part of the sideslopes and deeper soils on the lower part of the sideslope.

Although the areal extent of the residual soils developed on limestone is very small in Martin County, this does not in any way minimize the engineering problems associated with these types of soils. Solutioning of limestone is a major problem, and this often results in the creation of subsurface cavities

and sinkholes. The major area of sinkhole development is about 2,500 feet (0.74 km) west and 2,300 feet (0.67 km) north of the southeast corner of Section 36, T5N., R3W., near Indian Springs. Cavities and sinkholes create major problems in construction of highway embankments and foundations. This requires a careful and persistent plan for repairing sinkholes in order to minimize the potential of future collapse. The existence of sinkholes also dictates that minimal or no alterations of surface drainage be made as this will affect the subterranean drainage and, hence, the sinkholes in the areas. Deep foundations or deep excavations need to be carefully planned as weathering of the limestone bedrock is highly irregular.

As a result of reworking of the highly plastic clays in the limestone area, significant reduction in permeability results. The decrease in permeability arises from the destruction of the clay fabric caused by reworking. In its natural state, the permeability of the residual clayey soils is high due to its high internal drainage resulting from the well developed blocky soil structure. Soils developed on limestone residuum in general also have a high potential for pumping and as such are considered poor sub-grade material. These problems, therefore, dictate that a careful study be made concerning the engineering behavior of the soil and rock for all projects to be founded on these materials.

MISCELLANEOUS

Strip Mines:

Martin County exhibits old coal strip mines in the north-central part. Most of these mines have been abandoned and in most places the land has been reclaimed. Presently strip coal mining operations are in progress at the

northwestern part of the county, around the vicinity of Burn and Bramble. These are surface mines owned and operated by Black Mountain Pit, United Minerals Incorporated, and Seminole Coals Incorporated. Coal extraction in these places is from the "Coal Measures" Formation.

Underground Mines

There are no underground mines for coal. However, there are two underground mines from where gypsum is extracted from the lower St. Louis Limestone at depth of about 500 ft. (152 m) or more (David Schradle, Oral communication) below ground surface. These mines are located about two miles and about seven miles east of the county seat, Shoals. They are owned and operated by Gold Bond Building Products and United States Gypsum respectively.

Gravel Pits

There are several gravel pits in Martin County, most of which have been abandoned or temporarily suspended. The gravel pits are located on the outwash terrace or the alluvial terrace on the flood plain of the East Fork White River. Tertiary gravels, however, have been reported as existing on the hills at elevations as high as 600 feet (182 m), and along the valley walls of the East Fork White River. Small terrace gravels occur along U.S. 50 in the valley of West Branch a short distance east of Loogootee. The gravels here contain granite pebbles, and are probably of glacial origin.

Conglomerate deposits are common in the county. They are Pennsylvanian in age (27), and occur at the base of the Mansfield Sandstone. They have been mapped near Hindostan Falls and at various points in the central part of the county, especially in NE 1/4, Section 13, T3N, R4W.

Quarries

There are numerous quarries in Martin County, nearly all of which are sandstone quarries. An abandoned quarry is situated midway between the town of Loogootee and Shoals, in Section 21, T3N, R4W. Location of other quarries are shown on the map accompanying this report.

Minerals

Deposits of kaolin are found in Martin County (one near Dover Hill). This mineral is mostly used for whiteware, glass pots, and refractories. Limonite (siliceous iron ore) also occur in Martin County. They are found at the base of the Mansfield Sandstone and in the shales below the Mansfield [7]. Nodular masses and lenses of pyrite are abundant in the Pottsville shales in Martin County.

ENGINEERING PROBLEMS OF MARTIN COUNTY

GENERAL

The following section is devoted to the engineering problems associated with the soils and rocks of Martin County. Potential problems related to the soils and rocks in the county are specifically discussed for various types of engineering works. This is included to present the engineer involved with design and construction; and the construction and/or maintenance supervisor with a more accurate picture of the field conditions so that better decisions can be made at any stage of the project.

This section is divided into seven sub-sections.

1. Construction Material and Performance

2. Excavation and Foundation Problems

3. Slope Stability

4. Seismicity

5. Shale Fill and Embankments

6. Dams

7. Waste Disposal Systems

Construction Material and Performance

Martin County has abundant deposits of sand and gravel; however, because of the abundance of fines (silts and clay) in these deposits, they are generally not cost effective, as thorough processing of these materials is required before usage. Abundant supply of gravel comes from the numerous gravel pits along the East Fork White River and its tributaries. Most of the alluvial terrace materials in Martin County generally do not meet AASHTO grading requirements (Designation M 147) for subbase and base course, and, as such, are not in frequent use as subbase materials, because of the high potential for frost heave (See Appendix D). Crushed stone from limestone quarries constitute the major source of aggregate supply in Martin County. In the past, some sandstones were used as building stones.

With the exception of the areas in the eastern part of the county, around the valleys of Indian Creek and Lost River, where limestone formations are

near the surface, most of the soils of Martin County are acidic. The pH ranges from 3.7 to 6.5, for the moderately well drained soils of the bedrock, terrace, and flood plain areas. Significant corrosion of metal pipes and concrete structures in these areas is caused by the acidic nature of the soils (See Appendices B, C and D).

As in the neighboring Lawrence and Orange Counties, steel pipe corrosion in Martin County presents a serious problem to the engineer and maintenance personnel. The problem is attributed to the highly acidic nature of the soils particularly the residual soils with pH range between 3.7 to 5.5. Reduction in life span of metal pipes from 40 to 15 years are reported in nearby Orange County (28) where soils with similar acidic conditions are present. As a way of minimizing corrosion, aluminum pipes have been used (29). In general, these problems, compounded by the significant variation in soil types, requires that a site specific corrosion protection plan be developed for each pipe location.

Excavation and Foundation Problems

Excavation problems occur in the limestone areas in the north eastern part of the county. This is mostly the case where deep excavations or deep foundations are planned. These problems arise from the irregular weathering of the bedrock surface and solutioning of the limestone bedrock. A condition which generally leads to the development of subsurface cavities. This condition calls for an extensive repair of the sinkholes to minimize collapse when a structure is founded on these parent materials. In view of the sinkholes in limited areas, deep foundations are recommended for all moderate to large structures. Cracks as much as three inches wide are not uncommon in

houses and other structures that rest on shallow foundations. These are caused by differential settlement of the structures following solutioning of the subsurface bedrock and collapse of the bedrock.

The soils and parent materials in the sandstone-shale area (see map) provide adequate foundation support for light to moderately loaded structures. In these areas, sinkholes are virtually absent except in the vicinity of Dover Hill, where limestone is interbedded with the sandstone shale. In Shoals, where most of the heavy buildings in Martin County exist, foundation performance is moderate. Most of the buildings are founded on bedrock, and in some cases on the residual soils developed from the sandstone, shale, and interbedded limestone bedrocks. Problems arise mostly where the water table is high, as this causes slaking of the shale bedrock.

Structures built on the flood plains of Indian Creek in the towns of Trinity Springs, West Harrisonville, and Mount Olive require mat foundations.

Excavation problems are common in the flood plains and alluvial terraces. A dewatering plan is required in this area, because of the high permeability of the soil and the relatively high water table (2-11 feet (0.6-3 m) or more), (18,20,21) etc.). Typically, the sideslopes are not always braced, as most of the slopes are cut at an angle of repose. Nevertheless, where excavations are adjacent to highways or major buildings bracing is recommended. A similar recommendation is made for all the areas where outwash deposits occur.

Most of the bridge foundations are either H-piles, steel shell friction piles, or steel encased concrete piles (19,23). The major problem in the limestone area, is the collapse of pre-existing sinkholes in the vicinity of a bridge. A similar problem exists in the central part of the county, where

sandstone and shale are interbedded with limestone.

In other parts of the county, where bridge foundations are a concern, a few problems have arisen due to slope caving in sandy excavations. Blowouts are another problem associated with deep bridge excavation in the major alluvial valleys. These often occur when the formation pressure (that is the pressure in the sand and gravel deposits) is greater than the weight and friction of the soil in the bottom of the excavation. Where this kind of problem is anticipated (especially along the main flood plain of the East Fork White River Valley), soil borings should precede such excavations to locate sand and gravel layers with this potential to flood the excavation. Increasing the density of the drilling mud is one of the ways of keeping down the formation pressure to prevent blowout (30).

Slope Stability

Quite a few slope failures are reported in Martin County. These are mostly man induced, and related to the overall site characteristics or conditions. A failure occurred on U.S. 50, approximately three miles east of Loogootee (31). Although, the most plausible cause of this failure is not documented to the best of the writer's knowledge, there is a strong belief that lack of provision of drainage facilities and adequate specifications for selection of embankment materials are largely responsible for the failure. The abundance and distribution of the "Soft Shales" of the lower coal measure in this area, give a lot of credence to this failure hypothesis. Moreover, this portion of the highway was constructed before adequate testing procedures for determining degradation potentials of embankment materials were developed. Other ways by which slope instability occurs include a) saturation of slope,

b) overloading the head of the slope, c) oversteepening by a cut, d) removal of toe support, and e) presence of unfavorable system of joints.

Slope failures are not uncommon in alluvial terraces. Although these terraces offer good flood protection to structures built there, slope failure occurs following alteration of the natural slope by construction and increased runoff. Failures in these slopes usually are in the form of slumps, or as well defined failure scarps with distinct slopes as high as two feet or more. Because of the reasons outlined above, these slopes require minimal alteration due to construction activities and an effort to control runoff. Where lacustrine deposits abound, the natural slope angles are not to be used as guides for design as special analysis is required.

Slope instability in the sedimentary rock area is moderate to high. This is attributed to the seepage due to the layering and differential weathering of the sandstone-shale units. The soils are generally 0 to 10 feet (0-3 m) thick and are susceptible to sliding along the planar rock interface. Similar soils in Brown County are reported to be quite unstable at slopes of 30-45 degrees (32). Typically, the slope is initially weakened by removal of the toe (maintenance error or by construction activity), and then the slope fails upon saturation after heavy rainfall. Based on simple planar analysis, and field observations, it is found (see reference 31) that for a slope of 45 degrees, with unconfined compressive strength ranging from 250-500 psi, that the minimum critical soil depth ranged from 4 to 7 feet. In other words, a high potential for slope instability exists at depth of residual soils greater than 4 to 7 feet. In general the factor of safety decreased with increasing depth of residual soil.

Another kind of slope instability in Martin County is in the form of wedge failures. This is largely due to the nearly horizontal bedding and insignificant dip (one-foot per mile) of the rocks, and the abundance of widely spaced joints (3 to 15 feet) in the rocks. This is common in the south eastern and central portions of the county. In the west, slope instability is mostly related to the differential weathering of the sandstone-shale. In the remainder of the county, where the massive Mansfield Sandstone unit is dissected by numerous joint systems, moderate potential for slope instability by wedge failure mechanism exist. The unweathered rock mass quality in all these areas is considered "good" by the Congress of the Society for International Rock Mechanics (CIRS) rock-mass rating system (33). The rating system relates joint spacing and orientation, rock type, and rock orientation to construction problems in rock. However, because of the solutioning and subsurface cavities in the limestone bedrock this rating is not applicable in the northeastern part of the county where limestone bedrock outcrops on the surface.

Seismicity

Recently, there has been a considerable increase of interest in seismicity of Indiana and the central United States. This is attributed principally to two reasons. First, good quality seismicity data are needed because the design of major structures (nuclear power plants, bridges, dams, etc.) require the knowledge of areas of potential earth movement. Second, two earthquakes recently were felt in Indiana, indicating that the Middle West is not entirely seismically inactive. Thus in general, seismic stability should be considered as a major aspect of all stability evaluation for engineered structures to minimize loss of human life and damage to property. The

following discussion is an attempt to bring attention of the design engineers and highway supervisors to this important factor. This is particularly important when we recall that the present Indiana Building Code (1985 ed) does not give detailed guidance for design with respect to earthquake loads.

Figure 14 is a generalized map showing the different seismic risk zones of Indiana (37). As can be seen from the map over half of the state of Indiana is within seismic risk Zone 2, while the extreme southwest corner of the state is in Zone 3. Zone 2 corresponds to a "moderate damage" zone of earthquake intensity VII, while Zone 3 corresponds to "major damage" with intensities of VIII and higher. Martin County, falls within Zone 2, but it is only about 30 miles from the limits of Zone 3.

Earthquake intensity describes the acceleration or sensation that an earthquake causes at a location (see Table 5). Figure 15 is a map of the historical intensities of earthquake for the state of Indiana from 1811 to date (35). This map was prepared by superimposing isoseismal maps (maps showing lines of equal earthquake intensities) upon one another. The maximum historical intensity increases to the southwest part of the state from intensity V to intensity VIII at the junction of the Wabash and Ohio Rivers. The November 9, 1968 earthquake in south central Illinois was felt over approximately 580,000 square miles with a maximum intensity VII and a Richter Magnitude of 5.5 (36). The isoseismal map of this event is presented in Figure 16. As shown in this diagram, the intensity decreases with increasing epicentral distance, a fact which is of considerable importance in analyzing the effect of earthquakes on structures.

Table 6, modified from (38) is a list of the earthquakes centered in

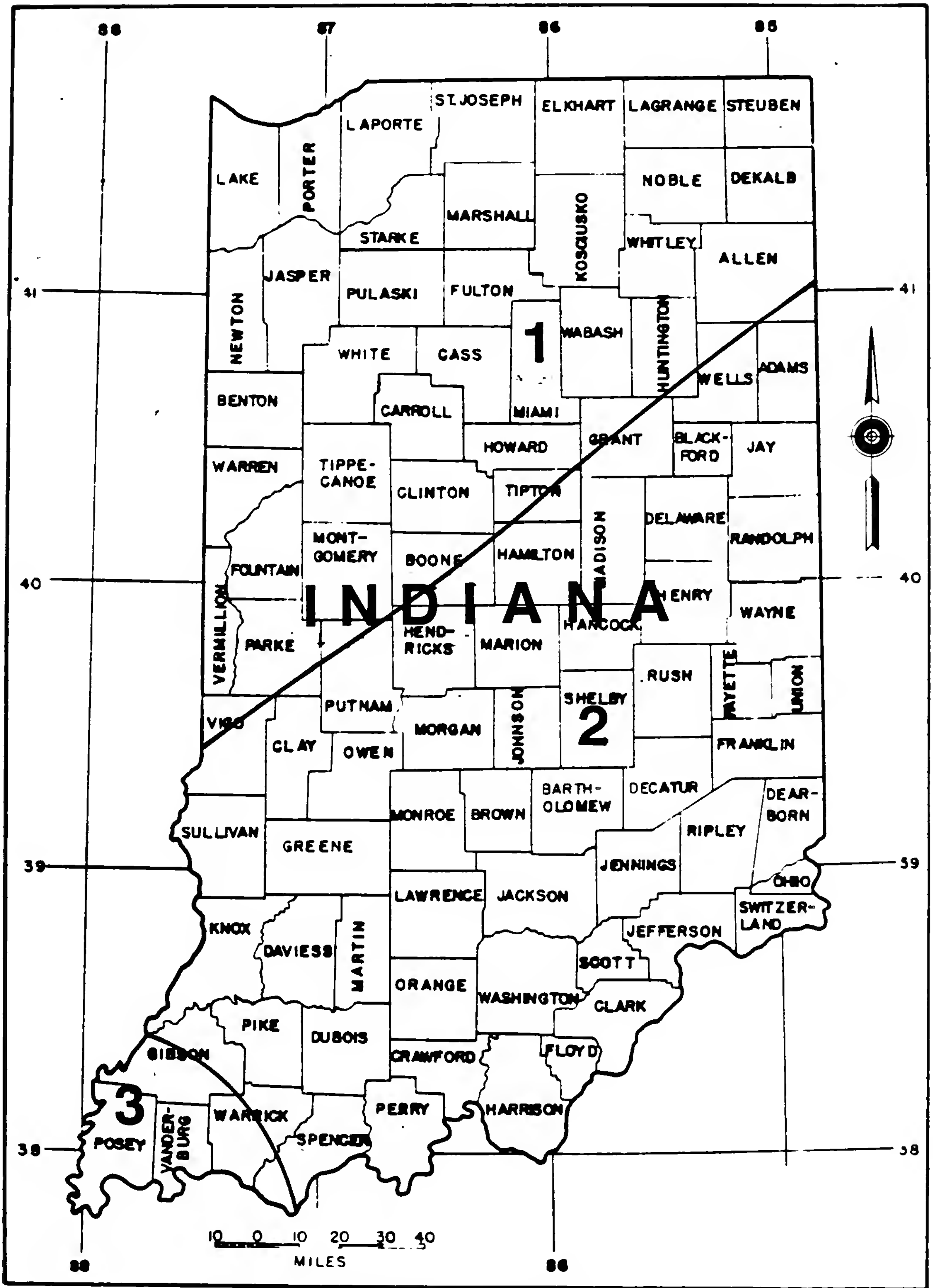


Figure: 14. Seismic Zone Map for Indiana. (37)

TABLE 5 (modified from (35))

MODIFIED MERCALLI INTENSITY SCALE OF 1931

I. Not felt. Marginal and long-period of large earthquakes.

II. Felt by persons at rest, on upper floors, or favorably placed.

III. Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.

IV. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of 4, wooden walls and frames crack.

V. Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.

VI. Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, and so on, off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken visibly, or heard to rustle.

VII. Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices, unbraced parapets, and architectural ornaments. Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.

VIII. Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.

TABLE 5 (Cont'd)

IX. General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames cracked. Conspicuous cracks in ground. In alluviated areas sand and mud ejected, earthquake fountains, sand craters.

X. Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dam, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.

XI. Rails bent greatly. Underground pipelines completely out of service. Earth slumps and land slips in soft ground.

XII. Damage nearly total. Waves seen on the gound. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

Construction Type

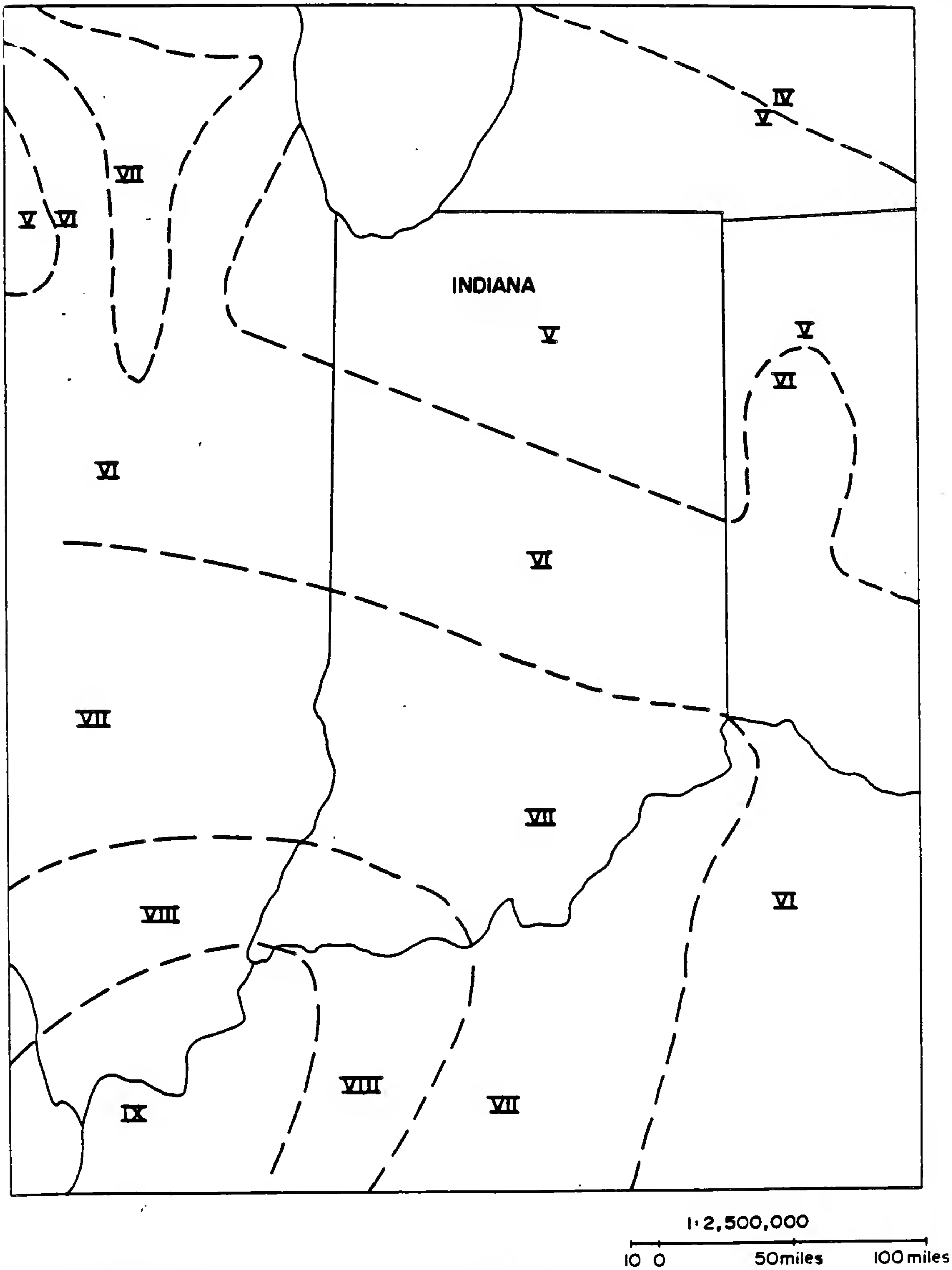
Masonry A, B, C, D. To avoid ambiguity of language, the quality of masonry, brick or otherwise, is specified by the following lettering (which has no connection with the conventional Class A, B, C construction).

Masonry A. Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces.

Masonry B. Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.

Masonry C. Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.

Masonry D. Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.



Roman Numerals Refer to the Modified Mercalli Scale of 1931

Figure 15. Maximum Historical Intensity Map of Indiana. -1811 to Date.(35)

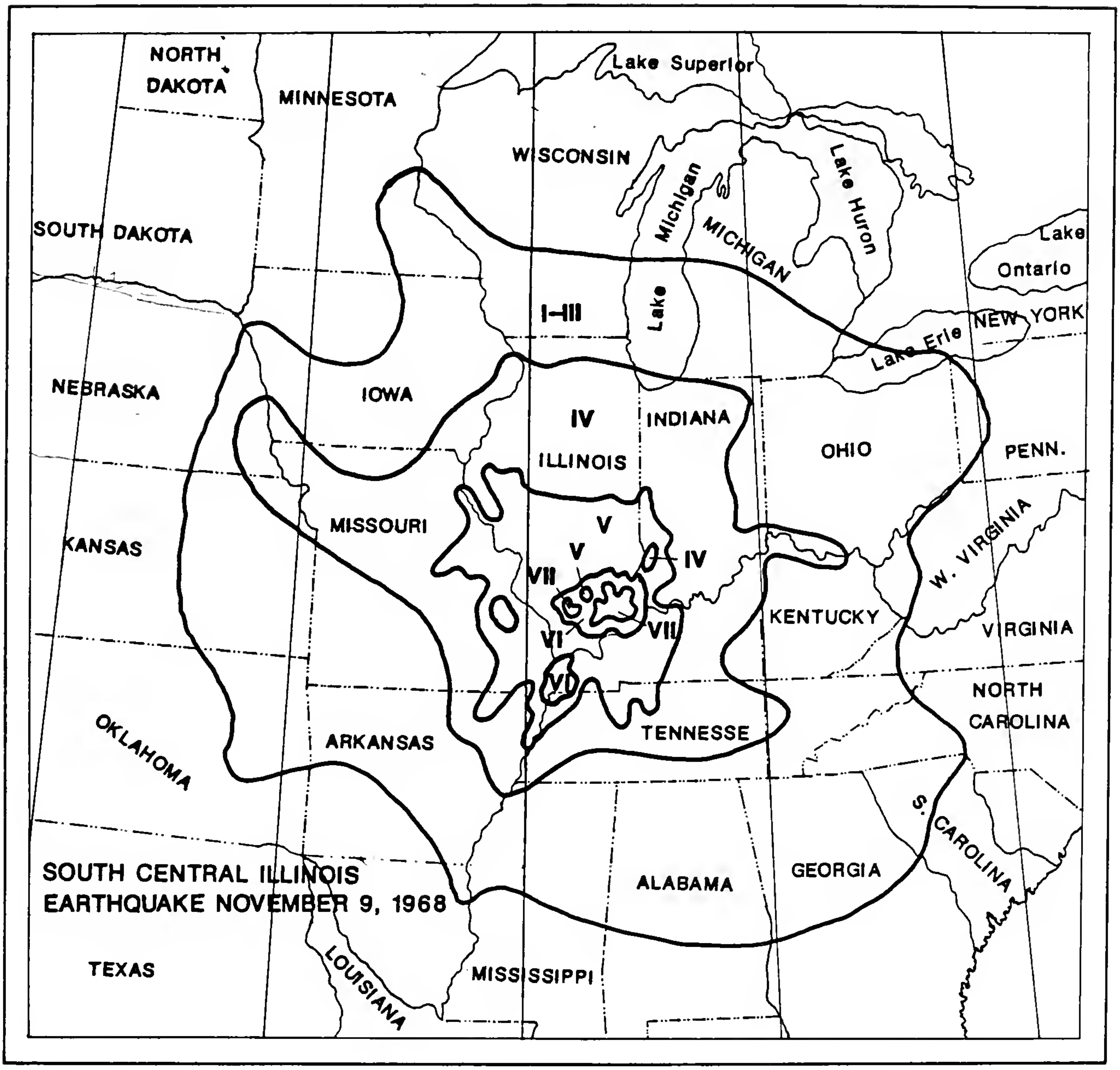


Figure 16. Generalized isoseismal map of the south-central Illinois earthquake. Intensities refer to the 1931 Modified Mercalli Scale. (36)

Table 6. Earthquakes Centered in Indiana (38)

Date	Location	Intensity (modified Mercalli)	Magnitude (Richter)
July 5, 1827	New Albany	—	—
August 6, 1827	New Albany	VI	5.0
August 7, 1827	New Albany	VI	5.0
September 25, 1876	Knox County	VI	5.0
May 26, 1877	New Harmony	III+	3.4
April 20, 1881	Goshen	IV	3.7
March 1, 1886	Butlerville	III+	3.4
August 13, 1886	Indianapolis	III+	3.4
February 6, 1887	Vincennes	VI	5.0
July 26, 1891	Evansville	VI	5.0
April 29, 1899	Dubois County	VI+	5.2
March 10, 1902	Hagerstown	III+	3.4
January 1, 1903	Hagerstown	II+	2.5
September 20, 1903	Morgantown	IV	3.7
November 20, 1903	Morgantown	—	—
May 8, 1906	Shelby County	III+	3.4
May 9, 1906	Columbus	IV	3.7
May 11, 1906	Petersburg	V	4.3
August 13, 1906	Greencastle	IV	3.7
September 7, 1906	Owensville	IV	3.7
January 29, 1907	Morgan County	V	4.3
September 22, 1909	Lawrence County	V	4.3
September 27, 1909	Vincennes	V	4.3
January 7, 1916	Worthington	III	3.0
May 25, 1919	Knox County	V	4.3
March 14, 1921	Crawfordsville	IV	3.7
March 31, 1921	Mount Vernon	IV	3.7
January 1, 1922	Mount Vernon	IV+	4.0
April 26, 1925	Vanderburgh County	V+	4.6
January 3, 1926	Princeton	III	3.0
February 14, 1929	Near Princeton	III+	3.4
January 5, 1931	Elliston	V	4.3
December 31, 1931	Petersburg	—	—
February 12, 1938	Porter County	V	4.3
December 28, 1940	Near Evansville	III	3.0
August 9, 1954	Petersburg	IV+	4.0

Indiana. The September 22, 1909 earthquake, was centered in Lawrence County, less than 10 miles from Martin County. One common feature about all the earthquake data is that the higher intensity areas and the contour lines tend to line up along the major river valleys. Also, the epicenters are located near or adjacent to principal river valleys (see Figure 17). This has been associated with the presence of unconsolidated sediments in these river valleys. These sediments tend to amplify the underlying base rock acceleration as compared to other locations at the same epicentral distance (35). The valleys of the East Fork White River in Martin County are areas for major concern in the event of an earthquake. Thickness of unconsolidated sediment reach approximately 200 feet (60 m) at various points along the river course.

Some information concerning minimum requirements for seismic design of dams is given in Table 7 (37). Other requirements to consider in any aspect of dam stability evaluation are piping, slope stability and seepage.

Another area of potential concern with respect to earthquakes is the potential damage to highways. Results of a theoretical study showing the effects of potential ground accelerations induced by earthquakes on highway structures along I-70 at Terre Haute, Indiana, near the Wabash River and easterly, along the Ohio River, to Louisville, Kentucky are shown in Table 8 (35). Amongst other things, this study concluded that water deposited, uniformly graded, fine sands and coarse silts are the most liquefiable sediments in the river valley. The grain size and strength characteristics of the most liquefiable soils in this area is shown in Figure 18 (modified from 35). Typically, those soils can be likened to some of the flood plain, terrace, and lacustrine plain sediments along the East Fork White River and

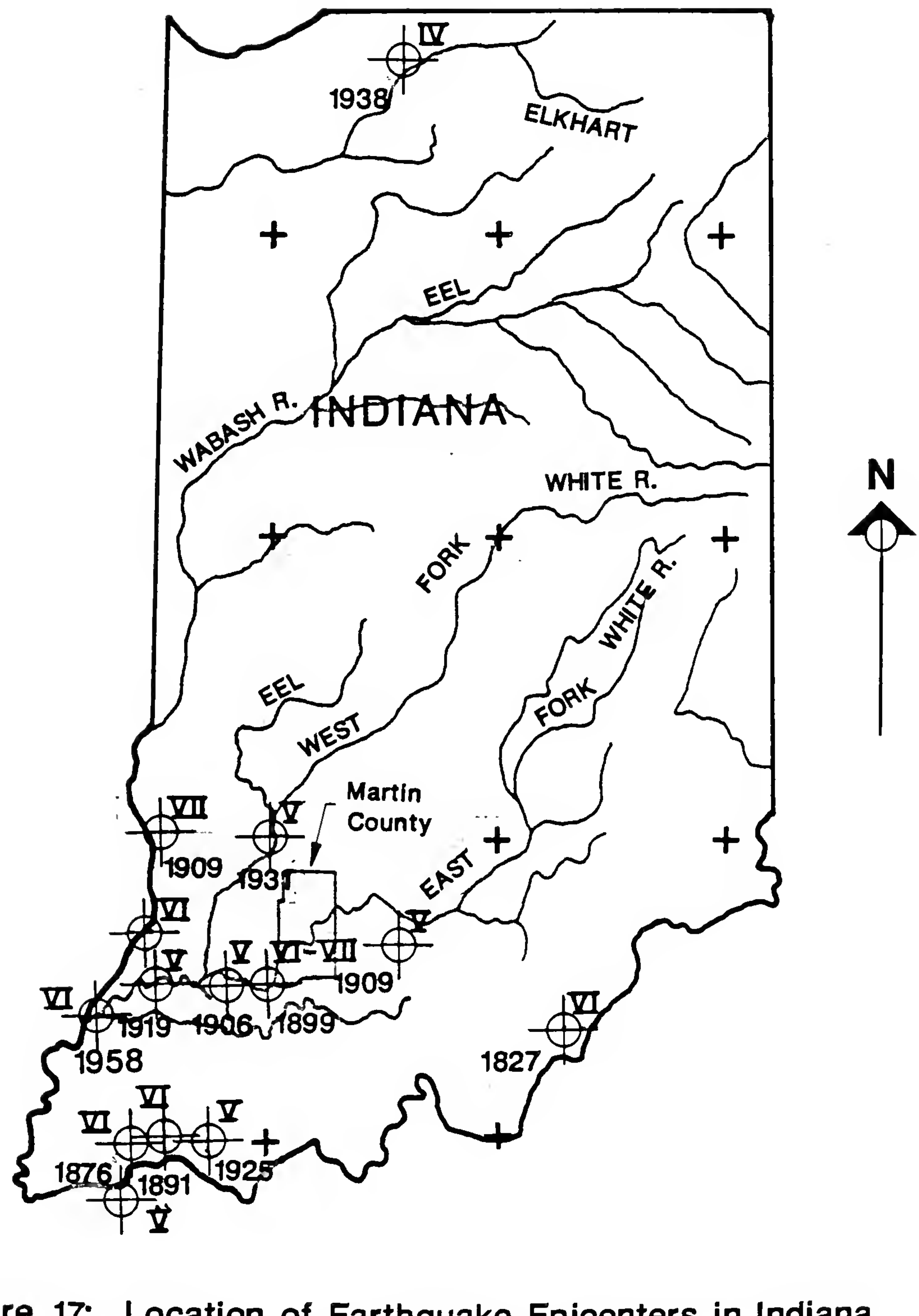


Figure 17: Location of Earthquake Epicenters in Indiana in relation to Major River Valleys. (Modified from (35))

TABLE 7. MINIMUM DESIGN REQUIREMENTS FOR DAMS, SEISMIC ZONE 2 AREA OF INDIANA (37).

HAZARD CLASS A --- Potential for Agricultural Damage

1. The fill will have a coarse grain downstream shell,
   or
   A self-healing GC*or GM*core
   or
   A downstream coarse grained transition section 0.25H < width > 15'
   or
   The minimum top width = 1.25 (H + 35) / 5
   and

2. Slopes will be designed for factor of safety = 1.0 with a seismic coefficient = 0.10 g

HAZARD CLASS B --- Potential for Property Damage

1. The fill will have a coarse grain downstream shell,
   or
   A self-healing GC or GM core
   or
   A downstream coarse grained transition section. 0.25H < width > 15'
   or
   The minimum top width = 1.25 (H + 35) / 5
   and

2. Slopes will be designed with a factor of safety = 1.1 with a seismic coefficient = .10 g
3. Additional freeboard = .05H will be provided.

HAZARD CLASS C --- Potential for Loss of Life

1. The fill will have a coarse grain downstream shell,
   or
   A self-healing GC or GM core
   or
   A downstream coarse grained transition section. 0.25H < width > 20'
   and

2. The minimum top width = 1.25 (H + 35) / 5
3. Slopes will be designed for a factor of safety = 1.1 with a seismic coefficient = .10 g
4. Foundation materials with a sensitivity > 4 will be removed or proven adequate.
5. Sand foundation materials with relative density < 70% will be removed, consolidated or proven adequate.
6. Additional freeboard = .05H will be provided

* GC = Clayey gravels, gravel-sand-clay mixtures.

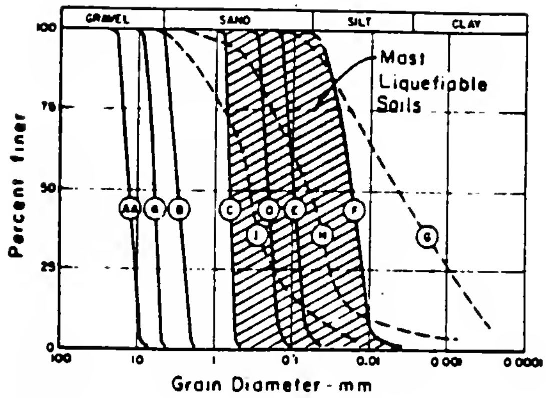
* GM = Silty gravels, gravel-sand-silt mixtures.

TABLE 8 (35)

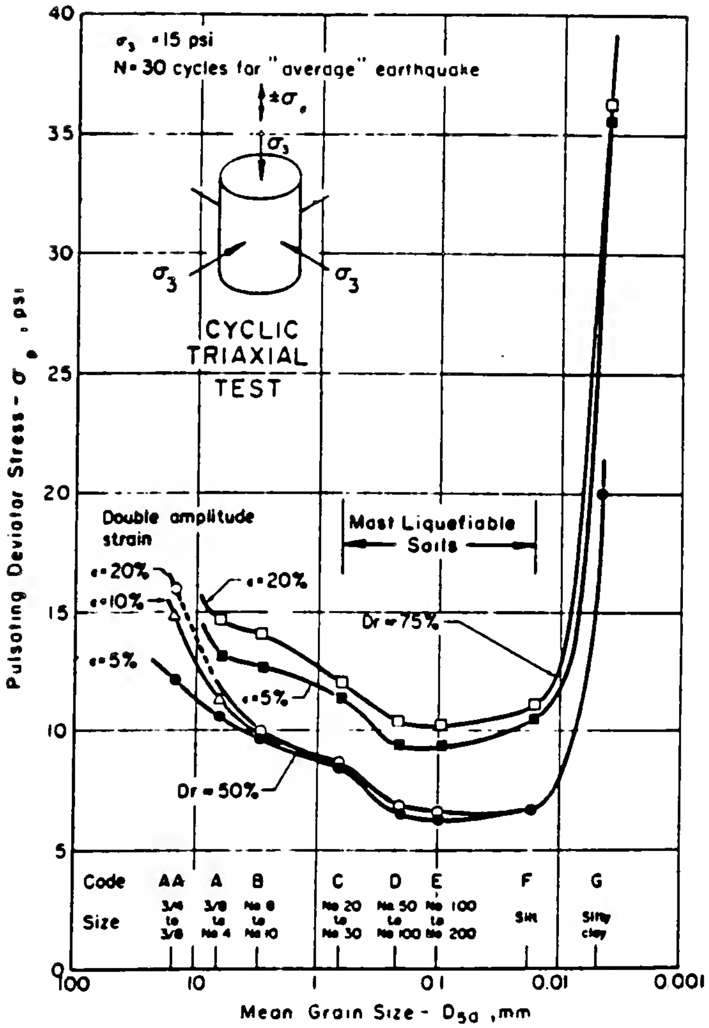
POTENTIAL GROUND ACCELERATION FOR SELECTED BRIDGE SITES
IN SOUTHWEST INDIANA ALONG WABASH AND OHIO RIVERS

(1) No.	(2) Route	(3) River	(4) Epicentral Distance (miles)	(5) M*	(6) Accel. %g	(7) Fault Name	(8) Remarks
1	I-70	Wabash	80	6.4	1	Wabash	
			200	7.2	2	New Madrid	
2	SR-154	Wabash	40	6.4	4	Wabash	
			180	7.2	2	New Madrid	
3	US-50	Wabash	10	6.4	13	Wabash	10 piers on the east bank of river. 10 or 25 feet of loose sand or silty sand. No information on pier elevation, probably founded on rock.
4	SR-64	Wabash	2	6.4	18	Wabash	
5	I-64	Wabash	2	6.4	18	Wabash	20' or 30' of loose sand in river. No information about piers.
6	US-460	Wabash	2	6.4	18	Wabash	
7	SR-62	Wabash	2	6.4	18	Wabash	
8	US-41	Ohio	20	6.4	7	Wabash	2 piers on the north bank of the river, remainder on soft soil above a loose saturated sand layer 15 ft thick (10 ft below ground surface) N(SPT) = 11 Blows/Foot.
			120	7.2	3	New Madrid	
9	US-231	Ohio	50	6.4	4	Wabash	15 ft of loose sand above present ground water table
			150	7.2	3	New Madrid	
			10	6.4	12	Rough Creek	
10	SR-37	Ohio	70	6.4	2	Wabash	
			170	7.2	3	New Madrid	
			30	6.4	5	Rough Creek	
11	SR-135	Ohio	100	6.4	2	Wabash	6 piers on the north bank of the river are founded on medium coarse sand with N(SPT) = 9 Blows/Foot.
			180	7.2	3	New Madrid	
			20	6.4	7	Rough Creek	
12	I-65 I-64	Ohio	100	6.4	2	Wabash	
			220	7.2	2	New Madrid	
			40	6.4	3	Rough Creek	

* M = Earthquake Magnitude on Richter Scale.



a. GRAIN-SIZE DISTRIBUTIONS



b. EFFECT OF GRADATION ON CYCLIC STRENGTH

(From Lee and Fitton, 1968)

Figure 18. Grain - Size & Strength Characteristics of Most Liquefiable Soils. (35)

Lost River in Martin County. This study recommended that, apart from the strength and flexibility of a structure, factors like epicentral distance, thickness of soil layers, dynamic soil properties (shear modulus and damping factor), magnitude, intensity, duration of the earthquake, foundation type, soil-structure interaction, and site resonance (the relation of the natural period of the ground to the natural period of the structure) be considered for all building codes.

Shale Fill and Embankments

Most of the state roads and major county roads within Martin County were constructed many years ago. They were constructed out of shales, particularly in the sandstone-shale plateau area. The embankment materials were not tested as the standards require today. Problems arise when, over time, the shale weathers into a soil-like material. Voids in the once hard material subsequently collapse giving rise to settlements and embankment slope instability.

In order to optimize and predict performance, a grading system of shales was developed at Purdue University (26). The system requires running several tests, the results of which are used to rate the shale. Correlation charts which compare this rating with construction practice and soil parameters are used for design.

One of these tests is called the slake durability test. In essence, this test simulates long term degradation due to weathering of the shale. Five, ten-gram shale pieces are placed in a rotating drum half submerged in a water sink. After 200 revolutions the shale pieces are taken out, oven dried, and then put through another 200 revolution cycle. The remaining shale pieces are

then weighed and the shale durability index is computed as follows:

$$I(d) = \frac{\text{Weight after 2nd Cycle}}{\text{Weight before 1st Cycle}} \times 100$$

Shales with I(d) less then 80 are classified as soil-like and are expected to act like soil if allowed to weather. The shales in the sandstone-shale plateau of the western part of the county (Wabash Lowlands), and the soft shales of the lower coal measures are classified as soil-like. The sandstone and shale formations which underlies the sandstone-shale plateau of the Crawford Upland are expected to be slightly more resistant to degradation but mechanically weak.

The Franklin rating chart (devised for classification of shales in terms of durability), shown in Figure 19, combines the slake durability test with the plasticity index. For Id(2) less than 80 and for Id(2) greater than 80 a point load test is used (39). The "R" ratings for the older Borden Group shales (New Providence and Locust Formations) which outcrop in the neighboring Lawrence County, are given in Table 9 (39). Many compaction degradation tests have been run on these shales (39,40). The results indicate that the shales are extremely difficult to break in spite of their long-term behavior as soil-like materials. A similar behavior is expected of the West Baden group of rocks. This condition requires the use of strict compaction control during construction. Figure 20a, gives the minimum lift thickness and compaction densities as a function of "R" (39). Figure 20b, shows the correlation between the "R" rating and drained shear strength parameters (39).

Within the West Baden and Stephensport group of rocks are sandstone and siltstone layers. These constitute a problem when used in conjunction with the shale as fill material as they break down even under reduced lift

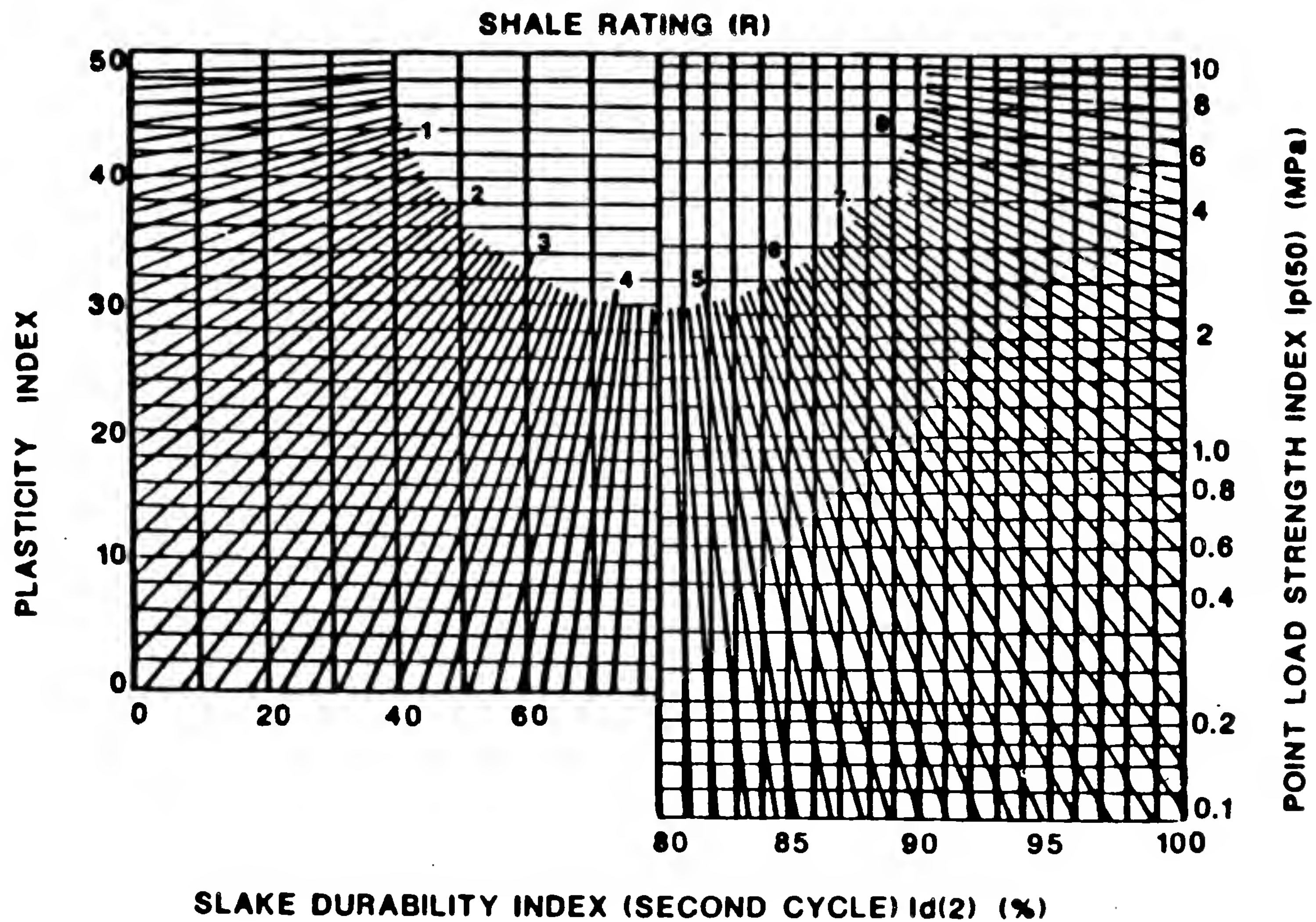


Figure: 19. Shale Rating Chart.(After Reference (39))

Index of Crushing and Coefficient of Variation for Impact Compaction Samples (39).

Shale	Effort Level $\frac{kN - m}{m^3}$	Index of Crushing: Mean Value (%)	Index of Crushing: Coefficient of Variation (%)
New Providence	1) 527	25.7	10.4
	2) 790	37.6	5.6
	3) 1451	43.9	5.0
	4) 2414	57.7	3.9

Average Properties of Compacted Shales (39).

ock Name	S.D.%	L.L.	P.I.	Estimated Franklin Rating R#	Max. Dry Density (PCF)	Optimum Moisture (%)	CBR 95% of Optimum	Rocklike or Soillike
w Providence Shale	69-71	27-34	5-10	4.2	119-121	10-13	8-11	soil
cust Point (upper)	67.6 (26.9)A	27-28	8	53.8	119-122	11-13	8-11	soil
(lower)	73 (42.6)A	27.2	8-9	54.2	123-127	10-11	10	soil

A - Based upon 500 revelations. The recommended laboratory (Oakland, 1982) procedure suggested that the shale durability index be computed after 2-200 revolution cycles. It has been found that beyond this recommended limit, the constant between soil-like soft shales is reduced.

B - Based upon a single cycle of 200 revolutions.

TABLE 9. THE 'R' RATINGS AND PROPERTIES OF SOME COMPACTED SHALES.

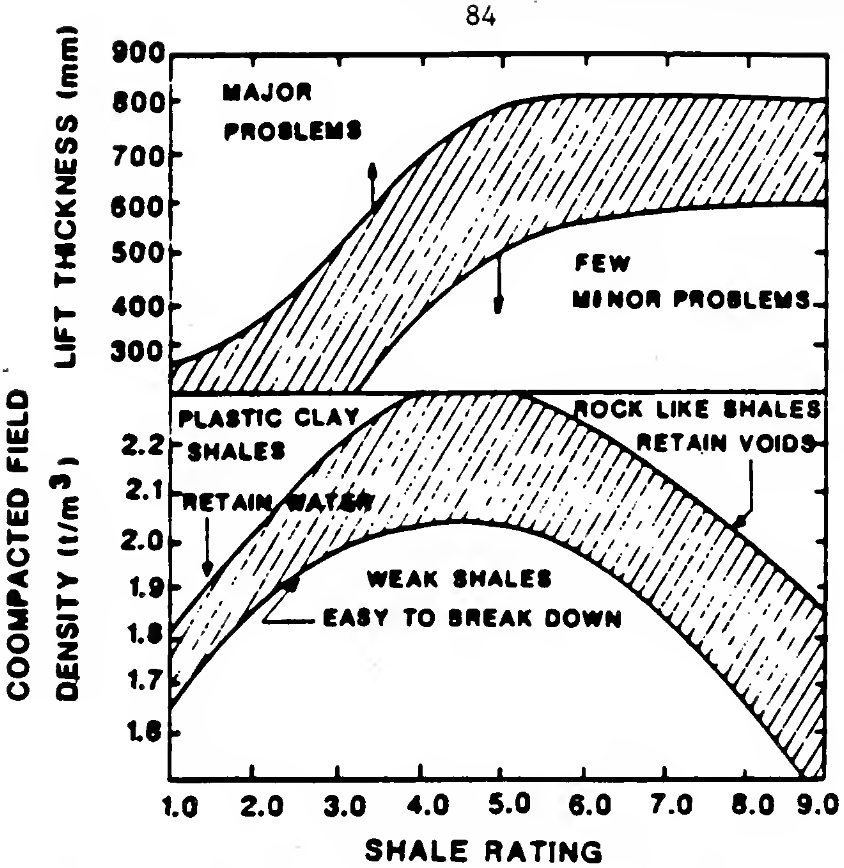


Figure: 20a Tentative Correlations Between Shale Quality, Lift Thickness and Compacted Densities (After Reference 39

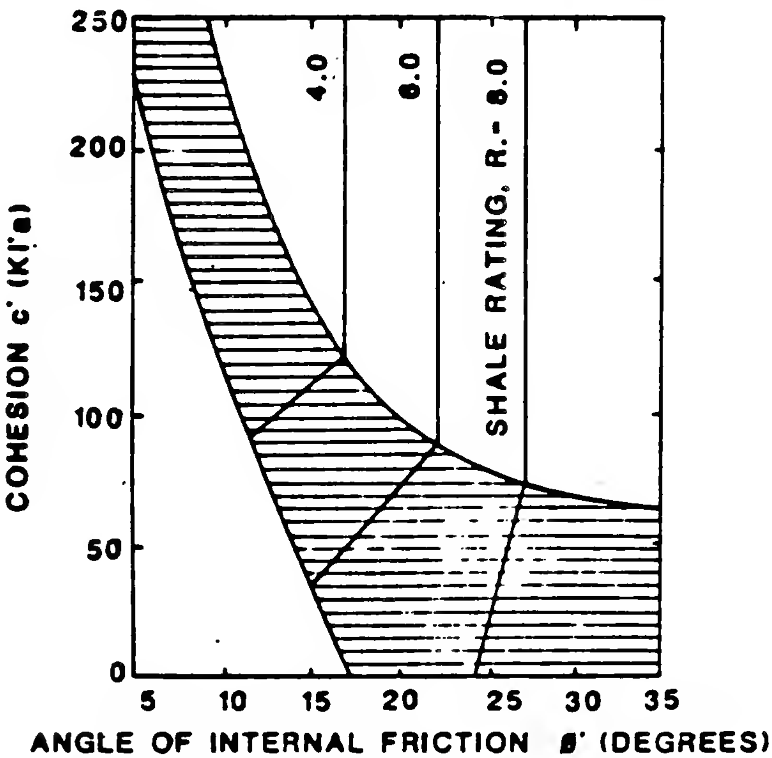


Figure: 20b Trends in Shear Strength Parameters of Compacte Shale Fills as a Function of the Shale Quality (After Reference 39)

thickness. This gives rise to poor performance as drainage and infiltration become uncontrolled. The problem is minimized by providing adequate drainage, encasing the clay layers, and using adequate vegetative cover to minimize infiltration.

Dams

The deep and narrow valleys in the central and eastern part of the county provide some favorable sites for possible location of dams. A few dams have been built in the western part of the county where the valleys are entrenched in the shales of the "Coal Measures" e.g Lake Greenwood.

The major concerns associated with dam foundation materials are compressibility, shear strength and leakage potential. Where thick deposits of highly compressible materials occur, attempt should be made to excavate and replace them with better fill materials. The foundation and abutment rocks should be carefully studied to assess the possibility of leakage. Where this is established, grouting can be used to remedy the situation.

There is an abundant supply of fill and embankment materials in Martin County. However, a qualitative and, of course, laboratory assessment of these materials should be made for each specific site before usage. An overall qualitative rating of the performance of the various soil associations in the county, as fill materials is presented in Table 10.

Waste Disposal

Suitable areas for waste disposal landfills in Martin County are present, however, there are many unsuitable areas. The unsuitable areas include 1) the flood plains, which are highly susceptible to flooding, 2) the terraces, which

Table 10. Summary Assessment and Rating for the Various Soil Parent Material Association in Martin County as Embankment Materials.

Soil Type	1 Compacted Permeability	2 In-situ Permeability	3 Compacted Shear Strength	4 Uncompacted Shear Strength	5 Piping Resistance
Windblown sand on terrace and sand dunes	Low to Moderate	Moderate to High	good	Low to Very Low	Moderate to Low
Loess on Illinoian Ground Moraine	Low	Very Low to low	Fair to good	Poor to fair	Low
Loess on lacustrine plains and terraces	Low to Moderate	Very Low to Low	Fair	Poor to Fair	Low
Loess on Outwash plains and terraces	Moderate	Moderate to High	Fair	Poor to Fair	Low to Very Low
Loess on sandstone shale	Low to Moderate	Moderate	Fair to good	Poor to fair	Poor to fair
Illinoian Ground Moraine (Till Plain)	Very Low	Low	Good	Fair	Fair to Good
Outwash plain and terraces	Moderate	High	Fair	Poor	Poor
Alluvial terrace	Moderate	Low to Moderate	Fair	Poor	Poor to Fair
Lacustrine terrace	Low to Moderate	Moderate to High	Fair to Good	Poor	Moderate to Low
Flood plains in Illinoian Till	Moderate to Low	Low to Moderate	Fair	Poor	Poor
Flood plains in Sandstone-shale	Moderate	Moderate to High	Moderate	Fair to Poor	Fair to Poor
Sandstone-shale limestone residual soil	Low to Moderate	Low to Moderate	Fair	Fair to Poor	Poor to Good
Sandstone Shale	Low to Moderate**	Low	Good	Good*	Low to Moderate

* Shale generally will degrade with time and considerable strength will be lost.

** Permeability decreases with time as shale degrades and voids collapse.

The ratings presented in this table represents average character of the soil groups. Actual conditions may vary considerably within a soil deposit and/or at a particular site.

are gravel acquifers, and 3) the bedrock benches (limestone bench and sandstone/shale bench), which are limited by the shallow depth to bedrock and possible sinkhole development. The lacustrine terraces, where elevated well above the flood plain and possessing enough surface area and flat clay soils, are a possibility. Upland surfaces with deep soils underlain by massive shale units are possible sites with minimum environmental problems. Around Loogootee, Illinoian drift is probably the best material. The low permeability and available cover material offer the best barrier against movement of leachate into groundwater system. Nevertheless, detail exploration of the Illinoian drift is necessary with emphasis placed on mapping and isolating sand and gravel seams and till fractures.

SUMMARY

A summary of the geotechnical problems of Martin County is presented in Table 11. Each of the parent-material types or soil types are rated qualitatively for likelihood of problems occurring for a variety of engineering activities. The ratings more or less reflect what is considered to be the average character of the soils.

In general, this report highlights and warns of the potential problems associated with the geologic parent materials of the county. The report and the map are very important tools for planning site investigations, and therefore, are not to be used as a design tool.

Table 11. Summary of Engineering Problems in Martin County, Indiana

Symbol Explanation

Likelihood of Major Problem Development

L - Low
M - Medium
H - High

Soil Property Rating

1 - Low
2 - Medium
3 - High

Landforms	Generalized Soil Texture	Cut Design: Soil Backslope Stability	Cut Design: Rock Backslope Stability	Cut Design: Groundwater Control	Cut Design: Erosion	Cut Design: Surface Drainage	Cut Design: Natural Slope and River Bank Stability	Embankment Files: Erosion	Embankment Files: Compacted Materials: Relative Permeability	Embankment Files: Compacted Materials: Shear Strength	Embankment Files: Compacted Materials: Compressibility When Saturated	Embankment Files: Compacted Materials: Workability	Embankment Foundation: Settlements	Embankment Foundation: Shear Strength	Embankment Foundation: Organic Matter	Highway Subgrade: Subgrade Support	Highway Subgrade: Frost Action	Highway Subgrade: Pumping	Highway Subgrade: Shrink-Swell	Foundation Design: Shallow Footings: Bearing Capacity	Foundation Design: Shallow Footings: Settlements	Foundation Design: Piles: Bearing Capacity	Foundation Design: Piles: Settlements	Foundation Design: Piles: Negative Skin Friction	Miscellaneous: Shallow Residential Septic Systems	Miscellaneous: Steel Corrosivity	Miscellaneous: Concrete Corrosion
Sand Dunes	Sand, silt, clay	L	--	M	H	L	L	H	3	L	L	L	L/M	L	L	L	L/M	L	L	L	L	L	L	L	H	L	L
Loess on Illinoian Ground moraine	Silt, clay, sand	L	--	L	M	M	L/M	M	1-2	L/M	M/L	M/H	L/M	L/M	L	L	M/H	M	M	L	L	L	L	L	H	M	H
Loess on Lacus-trine Plain	Silt, clay	M/H	--	M	M	M	M/H	M/H	1-2	M/H	M/H	H	M	M/H	M	L/M	M/H	M	M/H	M	H	M	H/M	M	M	M	M/H
Loess on Outwash plain and terrace	Silt, clay, sand, gravel	M	--	M/H	M	M	M	M	1-3	M	M	M	M	M	L/M	M	L/M	M	L/M	M	M	M/H	M	L/M	M	M	M
Loess on Sand-stone-shale-plateau	Silt, clay, sand	M/H	--	L/M	M	L/M	M	M/L	2-3	M/H	M	M/H	M/L	H	L	M	H	H	M	M	L/M	M	M/H	M	M	M	M
Illinoian Ground moraine	Silt, clay, sand	L	--	M	M	M	L	M	1	L/M	M/L	M/H	L/M	L/M	L	M	M/H	H	M	L	L	L	L	L	H	M	H
Outwash Plain and terraces	Silt, sand, gravel	L	--	M/H	M	L	L	M	3	L	L	L	L	L	L/M	L	L/M	L	L	L	L	L	L	L	L	L/M	L/M
Flood Plain	Silt, clay, sand, gravel	M	--	M	H	L/M	M	M	1-3	M	M	M/L	H/L	H/M	M/H	M	M	M/L	L	M/H	M	L/M	L/M	M	H	L	M
Alluvial Terrace	Silt, clay, sand, gravel	M	--	M/H	M	L	L	M	2	M/H	M/H	L/M	H	L/M	M/H	L	L/M	L/M	L	H/M	H/M	L/M	M	L/M	L/M	L/M	M
Residual soil on Bedrock defended terrace	Silt, clay	M	--	M/H	M	M	M/H	M	2	M	M	H	L/M	M/H	L/M	M/H	M/H	M/H	L/M	M/H	L/M	M/H	L/M	M	H	M	M

Table 11. (Cont'd)

Symbol Explanation

Likelihood of Major Problem Development

L - Low
M - Medium
H - High

Soil Property Rating

1 - Low
2 - Medium
3 - High

Landforms	Generalized Soil Texture	Cut Design						Embankment Files					Embankment Foundation			Highway Subgrade				Foundation Design					Miscellaneous		
								Compacted Materials												Shallow Footings		Piles					
		Soil Backslope Stability	Rock Backslope Stability	Groundwater Control	Erosion	Surface Drainage	Natural Slope and River Bank Stability	Erosion	Relative Permeability	Shear Strength	Compressibility When Saturated	Workability	Settlements	Shear Strength	Organic Matter	Subgrade Support	Frost Action	Pumping	Shrink-Swell	Bearing Capacity	Settlements	Bearing Capacity	Settlements	Negative Skin Friction	Shallow Residential Septic Systems	Steel Corrosivity	Concrete Corrosion
Lacustrine Plain	Silt, clay	M/L	--	M	M/L	M/H	M	L/M	1	H/M	H	H	H	M/H	H	M	H	M	M/H	M/H	H	M	H	H	H	M	H
Lacustrine Terrace	Silt, clay and sand	H	--	L	M/L	H	M	L	1	H/M	H	H	H	H	M	M	H	M	M/H	H	H	M	H	H	H	M	H
Residual Shale Sandstone-over-Limestone Plateau	Silt, clay	M	--	M	M	M	M	L/M	1-2	M	L/M	M	M	M	L/M	M	M/H	M	L	L/M	M	M/L	L/M	M	M/H	M	L/M
Residual Soil on Sandstone-Shale Plateaus	Silt, clay, sand	M/H	--	M	M	H	M	M	1-2	L/M	M/H	M	M	M	L	M/L	M	H	L/M	M	M	L	L	M	M/H	H	H
Residual Soil Sandstone-Shale Plateau Side-Slopes	Colluvial, silt, clay, rock fragments	M/H	--	M	M/H	M/H	M	H	1-2	M	M	M/H	M/H	M	L/M	L/M	M	M/H	H	M/H	M/H	M/H	H/M	M/H	M/H	M/H	L/M
Residual Soils in Limestone Bedrock Benches	Silt, clay, rock fragments	M/H	--	M	--	M	L	M	1	M	M	M/H	M/H	M	L/M	L/M	M	M	M	M/H	M/H	M/H	M	M	M/H	M/H	L/M
Sandstone-Shale	Rock	M	L	L	L	M	L	L	1	L	L	L	L	L	L	L/M	L/M	L	L	L	L/M	L/M	L/M	L/M	--	L/M	L/M
Limestone	Rock	H	M	L	L	H	L/M	L	1	L	L	L	L/M	L	L	L/M	M	L	L	M/H	M/H	M/H	L/M	M/H	L/M	M	L

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APPENDIX A

APPENDIX A-1
Boring and Laboratory Data
From Loogootee to US 50A, Shoals, Martin County (17).

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
1	1,2	US 50A	536+00	80'RT	528	1.0-4.0	Brown moist soft to medium sand loam	A-2-7				Bedrock Bench
	3,4, 5					4.0-10.0	Brown moist medium stiff clay, gray 6.0-8.0' reddish-brown below 8.0'	A-7-6				Auger refusal at 10.0 ft.
	1,2, 3					10.0-21.9	Dark gray thinly laminated shale		rock core rock core	54 60		
	4					21.9-36.5	Light gray coarse-grained limestone shale layers at 23.0', 28.0', 32.0'		rock core rock core	100 96		Lost water at 34.3 ft.
	5,6					36.5-53.3	Dark gray to dark red thinly laminated massive shale		rock core rock core	70 74		
	7					45-50	Sandstone		rock core	72		Bedrock: Sandstone/Shale
	9,10, 11					-86.1	Reddish-brown to light gray coarse-grained friable sandstone	@ 65.0' @ 85.0'	rock core "	81 100		
	11					86.1-87.1	Dark gray very fine-grained shaly sand-stone		rock core	100		
						87.1-89.3	Dark brown to gray fine to medium grained thinly laminated shaly sandstone		rock core "	100 100		

APPENDIX A-1 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description: Texture	Soil Description: AASHTO	Blow Per Foot	Recovery %	RQD	Notes
	12					89.3-110.5	Light Gray to Dark brown medium Coarse grained Sandstone w/clay layers between 80.5-90.5 6" shale layer at 92.6'	@ 95.0' @ 105.0'	Rock Core Rock Core	99 96		
Bottom of test boring 110.5												
2	1	US 50A	518+00	190'RT	624	0.0-1.5	Brown moist medium stiff clay loam	A-6				Auger refusal @ 1.5 ft.
	1	US 50A	518+00	190'RT	624	1.5-30.0	Tan to Red medium grained sandstone w/ clay layers less than 2" thick at 2.5', 3.31 5.5-15.5'	@ 7.5' @ 12.5' @ 25.0 @ 35.0	Rock Core " " "	100 90 90 66 88		Landform type: Bedrock defended terrace
3	1	US 50A	430+00	80'RT	605	0-3.5	Reddish Brown slightly moist medium stiff silty clay loam	A-4				Lacustrine Plain and Loess on Illinoian Ground Moraine
	2					3.5-5.0	Brown slightly moist medium stiff clay loam	A-6				
	3					5.0-7.0	Brown slightly moist soft to medium stiff	A-2-4				

APPENDIX A-1 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description: Texture	Soil Description: AASHTO	Blow Per Foot	Recovery %	RQD	Notes
	4					7.0-9.0	Sandy Loam Brown alightly moist medium atiff aandy loam	A-2-7				
3	1	US 50A	430+00	80'RT	605	9.0-36.5	light gray to dark Brown Medium-grained Sandstone		Rock Core " " "	92 84 0 0	23	Loess on lacustrine Plain and Illinoian Ground Moraine Bedrock: Sandstone Shale Rods fell without rotation 24.0-29.5 Lost water at 25.0
						36.5-39.0	Gray Sandy Shale		Rock Core	82		
						39.0-45.0	Gray very fine grained shaly sandstone		Rock Core	96	38	
						45.0-56.5	Gray Sandy massive to thinly laminated Shale		Rock Core	100		
	10					56.5-59.0	Gray fine to medium grained thin bedded sandstone		Rock Core	100	30	
	11					59.0-66.0	Gray to Brown thinly laminated very sandy Shale		Rock Core	100	30	

APPENDIX A-1 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
3	12,13	US 50A	430+00	80'RT	605	66.0-76.5	Gray Coarse to fine-grained sandstone		rock core "	98 98	32 32	
4	1,2	US 50A	399+00	80'LT	640	1.0-5.5	Brown moist medium stiff silty clay	A-4				Landform Type: Loess on Illinoian Ground Moraine Bedrock = Sandstone/ Shale
	3					5.5-6.5	Brown slightly moist medium stiff clay loam	A-6				
	1					6.5-7.8	Dark brown weathered sandstone		rock core	90	61.0	
	2,3 4					7.8-27.0	Brown to light gray fine to medium - grained sandstone		rock core " " "	90 100 100 90	" "	
	5,6, 7,8					27.0-49.8	Tan to gray medium to thinly bedded fine to medium-grained sandstone		rock core " " "	100 76 100 100	35 35 35 35	Clay seam at 36.0' - 41.0'
	9					49.8-52.0	Brown fine-grained sandstone		rock core	98	35	

APPENDIX A-1 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
5	1	US 50A	387+00	80'LT	664	0.0-3.0	Brown very moist to medium stiff silty clay loam	A-4				
	2,3					3.0-11.2	Brown slightly moist medium stiff silty clay brown gray below 7.0'	A-7-6(15)				Landform Type: Lacustrine Plain Bedrock-Sandstone Shale
	1					11.2-15.0	Gray to tan massive fine grained shaley sandstone		rock core	96	65	
	2,3					15.0-26.0	Gray shale		rock core "	100 92		
	4					26.0-31.0	Tan thinly laminated shaley sandstone		rock core	96	40	
	5					31.0-36.0	Tan to brown fine to medium grained sand-stone		rock core	100	40	
Bottom of test boring @ 36.0'.												
6	1	US 50A	382+25	80'RT	700	0.0-3.0	Brown very moist medium stiff silty clay loam	A-4				Landform Type: Flood Plain
	2					3.0-5.0	Brown moist medium dense sandy loam	A-2-4				
	3,4					5.0-10.0	Light gray-brown slightly moist medium dense sandy loam	A-2-4				

APPENDIX A-1 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
6		US 50A	382+25	80'RT	700	10.0-20.0	Light brown medium-grained sandstone, soft shale layers less than 3" thick at 11.5, 14.5, 17.0		rock core rock core	56 62	24	Landform Type: Flood Plain
						20.0-31.5	Gray shale		rock core "	100 100		
	5,6					31.5-40.0	Gray interbedded sandstone and shale		rock core "	100 100		
	7,8					40.0-48.5	Gray hard fine-grained sandstone w/ shale laminations		rock core "	100 100	59	Landform Type: Sandstone Shale Plateau
	8					48.5-49.0	Coal					
	9,10					49.0-61.0	Gray to black very sandy shale 1" seam of coal @ 54.3'		rock core	100		
Bottom of test boring at 61.0'.												
7	1,2	US 50A	366+00	80'LT	632	0.0-7.0	Brown moist medium stiff silty clay	A-7-6				Landform Type: Illinoian Ground Moraine Bedrock= Shale
	3					7.0-9.0	Gray-brown mottled moist medium stiff clay	A-7-6				

APPENDIX A-1 (Con't)

Boring No	Sample No	Highway Route No	Statioo No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
7	4	US 50A	366+00	80'LT	632	9.0-11.4	Gray-brown weathered shale					Landform Type: Illinoian Ground Moraine Bedrock= Shale
	1					11.4-18.7	Brown to gray soft shale		rock core	80		
Bottom of test boring at 18.7'.												
8		US 50A	360+25	80'LT	701	0.0-1.0	Road bed gravel					Landform Type: Sandstone/Shale bedrock
	1,2					1.0-7.0	Reddish-brown to gray slightly moist medium stiff clay	A-7-6				
	3					7.0-8.5	Brown weathered sandy shale					
	1,2, 3,4					8.5-26.5	Brown to gray inter-bedded shale and sandstone		rock core "	100 98	20 20	
	5,6, 7,8					26.5-46.5	Black to dark gray sandy shale w/ limestone 41'-43'		rock core " "	100 84 100		
	9					46.5-47.0	Black shale		rock core	100		
	9					47.0-50.0	Black to gray shaley sandstone		rock core	100		
	10					50.0-56.5	Gray to black shale		rock core	92		
Bottom of test boring at 56.6'												

APPENDIX A-1 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
9	1	US 50A	304+75	80'LT	710	0.0-5.0	Brown moist very stiff clay	A-7-6				Landform Type: Lacustrine Plain Illinoian Ground Moraine
	2,3, 4,5					5.0-15.5	Brown to gray moist stiff to hard clay loam	A-6				
	1,2					15.5-22.6	Light gray to brown massive fine-grained sandstone		rock core "	100 100	100	
	3,4					22.6-35.5	Light gray to dark gray thinly inter-bedded sandstone and shale		rock core "	100 100	15	
	5,6, 7,8					35.5-55.5	Gray fine medium sandstone interbedded w/very thin shale layers		rock core " "	100 100 98	25 25 25	
	9,10					55.5-64.8	Black to gray inter-bedded fine-grained sandstone and shale		rock core "	9 100	25 25	Sandstone and Shale Bedrock
						64.8-90.5	Light gray to bluff fine-grained massive sandstone		rock core "	100 100	83 83	
Bottom of test boring at 90.5'.												
10	1,2	US 50A	235+00	80'LT	523	0.0-4.0	Brown moist soft to medium stiff silty clay loam	A-7-6				Landform Type: Illinoian Ground Moraine Bedrock: Sandstone/Shale

APPENDIX A-1 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
10	3,4, 5	US 50A	235+00	80'LT	523	4.0-10.0	Brown moist medium stiff clay loam	A-6				Auger refusal at 10.0 feet
	1					10.0-13.0	Brown soft shale w/ thin layers of fine-grained sandstone		rock core "	43 43		Landform Type: Illinoian Ground Moraine Bedrock: Sandstone/Shale
	2					13.0-23.4	Gray thinly laminated shale w 3"-4" sand-stone seams @ 15.0', 16.0', 18.0'		rock core	53		
	3					23.4-30.0	Brown to gray thinly laminated sandy shale w/fractures and sand-stone layers		rock core	70		
	4,5					30.0-35.7	Gray thinly laminated shale		rock core	96		
						35.7-46.0	Brown medium to course grained sand-stone w/thin clay seams 36.0-38.0		rock core rock core	100	23	
Bottom of test boring at 46.0'.												
11	1	US 50A	529+00	℄	455	0-3	Brown moist medium stiff silty clay loam	A-4	4 4/4	50		Landform Type: Sandy Terrace Deposit
	2,3					3-9.5	Brown very moist very loose sandy loam	A-2-4	1 1/1 1 1/1 2 1/1	100 100 100		
	4,5 6					9.5-21.5	Gray wet loose sandy loam w/trace organic	A-2-4	1 1/0 3 3/4 2 5/5	100 75 100		Heaving sands at 18.5', water introduced into hole at 18.5'

APPENDIX A-1 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
11	7	US 50A	529+00	℄	455	21.5-26.0	Brown wet loose sand		1 0/7	100		Landform Type: Sandy Terrace Deposit
	8					26.0-27.2	Brown weathered sandstone		50/0.2	10		
Bottom of test boring 27.2 caved to 8.0 ft., Groundwater noted on rods at 13.0 ft., Groundwater level at the end of 24 hours after completion 4.0 ft.												
12	1	US 50A	495+50	42'LT	457	1.0-3.0	Brown moist silty clay	A-7-6	5	100		@ 6.0-7.5, W_n= 19.0 @ 8.5-10.0, W_n= 19.1 @ 13.5-15.0, W_n= 31.6 q_u=0.65 tsf, ε_f= 9.0%
	2,3					3.0-7.0	Brown to gray moist soft clay loam	A-6	4	100		γ_d=100.9 pcf, W_n=24.7
	4,5					7.0-17.5	Brown to gray moist very loose sandy loam	A-2-4	3	100		q_u=1.01 tsf, ε_f=8.0% γ_d=104.6, W_n= 22.2
	6,7, 8,9					17.5-37.5	Gray moist soft to stiff clay blue-green below 32.5 ft.	A-7-6				q_u=0.56 tsf, ε_f= 17.5% γ_d=100.6 pcf, W_n= 24.3
	10					37.5-40	Gray moist very stiff silty clay	A-7-6	19	100		

APPENDIX A-1 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
13	1,2 3		483+03	42'LT		1.0-9.5	Brown moist soft to medium stiff silty clay	A-7-6	4	60		q_u=1.19 tsf, ε_f= 2.7% γ_d=106.5 pcf, W_n= 22.3%
						9.5-14.5	Gray wet very loose sandy loam w/trace organic	A-2-4	4	100		q_u=0.6 tsf, ε_f= 7.1% γ_d=99.2 pcf, W_n= 23.1
						14.5-19.5	Gray moist soft clay	A-7-6	12	100		q_u=1.43 tsf, ε_f= 8.0% γ_d=106.7 pcf, W_n=23.6%
	6,7, 8,9					19.5-39.0	Gray moist soft to stiff silty clay loam	A-4	15	100		q_u=0.96 tsf, ε_f= 6.2% γ_d=102.8 pcf, W_n= 23.9%
						39.0-44.9	Gray wet loose to dense sand	A-2-4	76	100		
Bottom of test boring 44.9 caved to 37.0 feet.												
14	1,2, 3	US 50A	442+50	100'RT	472	1.0-8.0	Brown to gray mottled wet very soft to soft silty clay	A-7-6	2 1/3	100		Landform Type: Flood Plain in Illinoian Ground Moraine γ_d=98.3 pcf W_n=23.6%
	4					8.0-14.5	Gray wet soft silty clay loam w/trace organic	A-4	1 2/3	100		Boulder @ 12.0 feet

APPENDIX A-1 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description: Texture	Soil Description: AASHTO	Blow Per Foot	Recovery %	RQD	Notes
14	5	US 50A	442+50	100'RT	472		Gray wet medium stiff clay loam	A-6	8 4/6	60		Landform Type: Flood Plain in Illinoian Ground Moraine
Bottom of test boring and Auger refusal at 17.5', Hole caved to 7.0'												
15	1,2	US 50A	440+50	42'RT		1.0-5.5	Brown to gray mottled moist medium stiff silty clay loam	A-4	2 3/4 3 5/4	100 100		Landform Type: Illinoian Ground Moraine
	3					5.5-8.5	Brown wet medium stiff clay loam	A-6	2 3/6	100		
	4					8.5-12.5	Gray moist soft silty clay loam	A-4	1 2/2	100		LL=43.0, PL=20.0 PI=23.0, γ_d=99.6 pcf W_n=27.3%
	5					12.5-17.5	Gray moist medium stiff clay	A-7-6	4 5/5	100		
	6,7, 8					17.5-32.5	Gray moist medium stiff to very stiff silty clay, rock fragments below 27.5'	A-7-6	5 6/8 4 3/4	100 100		LL=34.0, PL=16.0 PI=18.0, q_u=0.98 tsf ϵ_f=10.7%, pcf= 103.1 pcf W_n= 27.8
	9,10, 11,12					32.5-50	Gray moist medium stiff to hard clay grayish green below 37.5'	A-7-6	4 5/5 4 5/7 8 11/13 25 44/55	100		
Bottom of test boring 50', Hole caved to 31.0'.												

APPENDIX A-1 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
16	1	US 50A	323+00	80'RT	516	1.0-3.0	Brown moist stiff sandy loam	A-2-7	4 6/5	70		Landform Type: Flood Plain bordered by Outwash Plain and Ground Moraine
	2					3.0-5.5	Brown to gray moist stiff clay loam	A-6	11 6/7	60		
	3,4					5.5-12.5	Gray wet medium dense sandy loam	A-2-4	4 7/7 11 12/10	80 20		
	5,6 7,8 9					12.5-35.0 23.9-25.0 28.8-30.0	Gray wet soft to medium stiff clay	A-7-6	5 5/5 2 2/3 2 2/3 3 4/4 3 5/5	100 100 100 100		@ 15.0-17.0' q_u=1.23 tsf ϵ_f= 5.4% γ_d=104.3 pcf W_n = 22.5 @ 20.0-22.0' LL=49; PL=22; PI =27.0 γ_d=81.9 pcf W_n = 41.8%
	10					35.0-42.5	Gray moist soft silty loam w/trace organic	A-7-5	2 2/2	100		
	11,12					42.5-52.5	Gray moist medium stiff clay	A-7-6	3 4/4	100		
	13,14					52.5-62.5	Gray wet medium dense to hard sandy loam	A-2-7	9 14/18 8 7/7	100		
						63.9	Gray weathered shale		50/4	50		

Bottom of test boring 63.9, Hole caved to 7.0'

APPENDIX A-1 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
17	1	US 50A	220+53	42'RT	468	1.0 1.0-3.0	Topsoil Brown moist soft clay loam	A-6	2 1/3	100		
	2					3.0-5.5	Brown slightly moist medium stiff clay loam	A-4	4 3/4	60		
	3					5.5-8.0	Brown moist stiff clay loam	A-6	5 7/8	100		q_u = 0.57 failure strain(%) 3.5 Dry Density= 80.7 pcf, W_n=41.8
	4,5					8.0-13.0	Gray to brown mottled soft to medium stiff silty clay	A-7-6	2 2/3 2 3/3	90 25		
	6					13.0-17.5	Gray moist medium stiff clay	A-7-6	5 4/5	100		
	7					17.5-23.5	Gray moist soft clay loam	A-6	2 2/3	100		Boulders at 23.5'
Bottom of test boring and auger refusal at 23.5', Hole caved to 19.0'												
18	1,2	US 50A	247+00	42'RT	458	1.0-5.5	Brown to gray moist medium stiff to stiff silty clay	A-7-6	3 4/5 3 5/7	100 50		Landform Type: Sandstone/Shale Plateau
	3,4					5.5-13.7	Brown to gray moist stiff clay	A-7-6	4 5/9 5 6/6	95 75		

APPENDIX A-1 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
18	5,6	US 50A	247+00	42'RT	458	13-7-20.0	Brown wet soft silty clay loam	A-4	2 2/2	100		Landform Type: Sandstone/Shale Plateau q_u = 0.73 Failure Strain(%) = 6.2, Heaving Sand 23.5'-28.5' Mud introduced into hole @ 23.5' Dry Density = 95.2 pcf W_n = 27.3
	7					20.0-27.5	Gray wet medium dense sand	A-2-4	1 5/7	100		
	8					27.5-32.5	Gray wet medium dense sandy loam	A-2-4	12 10/12	100		
	9					32.5-35.0	Gray wet dense sand	A-2-4	10 23/25	95		

Bottom of test boring 35.0'. Hole caved to 24.0 feet.

Appendix A-2.

S.R.550, Bridge Over East Fork
of
White River
1 1/2 Miles S.E. of Loogootee (20)

Boring No.	Sample No.	Highway Route No.	Station No.	Offset Ft.	Ground Elevation Ft.	Sample Depth Ft.	Soil Description: Texture	Soil Description: AASHTO	Blow per Ft.	Recovery	RQD	Grain Size Distribution: Gravel	Sand	Silt	Clay	LL	PL	PI	Notes
19	1SS	550		10' LT	452.5	1-6.5	Brown Moist Stiff Silt with trace of Organics		8	100									
								A-4											
	2SS																		
	3SS					6.5-13.5	Brown Moist Stiff to very stiff												
							Silt	A-4	20	100									
	4SS																		
	5SS					13.5-18.5	Brown Mottled Gray Moist Stiff												Alluvial/ Sandy Terrace
							Silty Loam A-4	A-4	15										
						18.5-24.0	Gray Wet Med.		24	75									
	6SS						Dense Silty Loam	A-4											
	7SS					24.0-30.0	Gray Wet Medium to Dense Sand	A-2-4	25	70									
									45	100									
	8SS																		
20		550			436.0	1.0-5.0	Drilled in 5 feet of water												
	1SS					5.0-7.0	Gray Wet Soft Loam with Organics		5	100									
	2SS					8.5-10.0	Gray Moist	A-2-4	10	20									Flood Plain

S.R.550, Bridge Over East Fork
of
White River
(Continued)

Boring No.	Sample No.	Highway Route No.	Station No.	Offset Ft.	Ground Elevation Ft.	Sample Depth Ft.	Soil Description: Texture	Soil Description: AASHTO	Blow per Ft.	Recovery	RQD	Grain Size Distribution: Gravel Sand Silt Clay	LL	PL	PI	Notes
	3SS					11.0-12.5	Loose Medium		45	100						
	4SS					13.5-15.0	Dense to Dense		22	10						
	5SS					18.5-20.0	Sand		21	30						
	6SS					23.5-25.0			35	100		Boring terminated at 25.0 feet				
21		550	106+35	10 RT	439.8	1.0-9.0	Water			Drilled in 9.0 feet of water						
	1SS					10.0-11.5	Brown Wet		19	60						
	2SS					12.5-14.0	Medium Dense	A-1-a(1)	16	70						
	3SS					15.0-16.5	Gravelly		21	70		3.0' Heave				Flood Plain
	4SS					17.5-19.0	Sand		36	50		6.0' Heave				
	5SS					22.5-24.0	Gray to Brown									
	6SS					27.5-29.0	Wet Dense		20	100		12.0' Heave				
	7SS					32.5-34.0	to Medium	A-2-4	25	100						
	8SS					37.5-39.0	Dense Sand		26	100		12 72 ← 16 →	NP	NP	NP	
Boring terminated at 39.0 feet																
22		550	107+67	10 RT	438.0	1.0-6.0	Water			Drilled in 6.0 feet of Water						
	1SS					7.0-8.5	Brown		9	70						
	2SS					9.5-10.0	Wet loose		12	100						Flood Plain

S.R.550, Bridge Over East Fork
of
White River
(Continued)

Boring No.	Sample No.	Highway Route No.	Station No.	Offset Ft.	Ground Elevation Ft.	Sample Depth Ft.	Soil Description		Blow per Ft.	Recovery	RQD	Grain Size Distribution				LL	PL	PI	Notes
							Texture	AASHTO				Gravel	Sand	Silt	Clay				
	3SS					12.0-13.5	to	A-2-4	12	20									
	4SS					14.5-16.0	Medium Dense		19	20									
	5SS				24.5	19.5-21.0	Sand		23	100									
	6SS					24.5-26.0	Brown wet	A-1-6	37	60		5' Heave							
	7SS					29.5-31.0	Dense to very dense Gravelly		53	100		7' Heave							
						34.5	Sand												
22	8SS	550	107+67	10' RT	438.0	34.5-36.0			57	100		9' Heave							
	9SS					39.5-41.0	Brown Wet		56	40		10' Heave							Flood Plain
	10SS					45.5-46.0	Very Dense		59	20									
	11SS					49.5-51.0	Silty Loam		70	0		13' Heave							
	12SS					54.5-55.0			50.0	0		Sample of Heave							
Boring terminated at 55.1 feet																			
23	1SS	550	108+73	18' LT	459.3	1.0-1.5	Brown Moiat Soft Silt with trace of	A-4-(2)	4	80		0	5	93	2	25	22	37	
	2SS					3.5-5.0	Fine Sand												
	3SS					6.0-7.5	Brown Moist loosa to Medium Dense	A-4(0)	11	40		0	47	51	2	NP	NP	NP	
	4SS					8.5-10.0	Silty Loam		15	60									

S.R.550, Bridge Over East Fork
of
White River
(Continued)

Boring No.	Sample No.	Highway Route No.	Station No.	Offset Ft.	Ground Elevation Ft.	Sample Depth Ft.	Soil Description		Blow per Ft.	Recovery	RQD	Grain Size Distribution				LL	PL	PI	Notes
							Texture	AASHTO				Gravel	Sand	Silt	Clay				
23	5SS	550	106+73	18'LT	459.3'	13.5-15.0	Brown Moist Stiff	A-4	15	70									
						18.5	Silty Loam												
	6SS					18.5-20.0	Brown Moist Med	A-4	14	90									Alluvial Terrace
	7SS					23.5-25.0	Dense Silty Loam		30	20									
	8SS					28.5-30.0	Brown Moist to Wet Medium Dense to Dense Sand	A-2-4(0)	35	50		12	72	16		NP	NP	NP	

Boring terminated at 30.0 feet

APPENDIX A-3.

Boring and Laborstory Data for U.S. 50 from Shoals to Huron.

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description: Texture	Soil Description: AASHTO	Blow Per Foot	Recovery %	RQD	Notes
24	1,2,3	US 50B	832+00	80'LT"K"	634.0	0.0-5.5	Brown moist medium stiff silty loam	A-4				Sandstone Shale Plateau
	4,5,6, 7,8,					5.5-16.5	Brown moist medium stiff clay	A-7-6				
	9,10,11					16.5-20.5	Brown moist dense sand (weathered from sandstone)	A-3				Set casing to 20.5' Auger refusal at 20.5'
	1 2					20.5-35.0	Tan fine grained sandstone massive bedding well ce- mented w/little mica		rock core rock core	95 100		
	3					35.0-46.7	Tan fine grained sandstone well ce- mented		rock core	100		
	4 5 6,7					46.7-63.0	White medium grained limestone with some fossils		rock core rock core rock core	95 100 100		
	7,8 9					63.0-72.3	Greenish gray hard sandy shale w/lenses of laminated sand- stone		rock core rock core	100 100		
	10 11					72.3-104	Brown fine grained sandstone with thinly laminated shale		rock core rock core rock core	100 100 100		

Bottom of test boring 104': Groundwater level at completion: 14.0 ft; after 24 hours 16.5 ft.

APPENDIX A-3 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description: Texture	Soil Description: AASHTO	Blow Per Foot	Recovery %	RQD	Notes
25	1,2	US 50B	879+50	80'RT"K"	686.0	0.0-4.9	Light brown moist medium stiff silty loam	A-4(0)				Sandstone/Shale Plateau
	1 2 3					4.9-17.5	Gray to brown iron stained weathered sandstone w/shale partings		rock core rock core rock core	100 100 100		
	4 5 6					17.5-34.1	Interbedded gray sandstone and dark gray shale		rock core rock core rock core	75 100 100		
	7					34.1-42.9	Light brown weathered sandstone		rock core rock core	100 50		
	8					42.9-44.9	Red-brown weathered broken sandstone		rock core	50		
	9,10 11,12					44.9-83.4	Interbedded gray sandstone and dark gray shale		rock core rock core rock core rock core	65 100 100 100		

APPENDIX A-3 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description: Texture	Soil Description: AASHTO	Blow Per Foot	Recovery %	RQD	Notes
25	13,14 15,16	US 50B	879+50	80'RT"K"	686.0	44.9-83.4	Interbedded gray sandstone and dark gray shale		rock core " "	100 100 100		Sandstone/Shale Plateau
	16,17					83.4-84.9	Yellowish-brown sandy shale w/clay partings		rock core	90		
	17,18					84.9-96.9	Dark brown to gray iron stained, weathered sandstone		rock core "	100 100		
	19					96.9-100.4	Brown-red broken sandstone, clay partings (98.9-99.1')		rock core	99		
	20,21 22					100.4-116.9	Gray massive fossiliferous limestone		rock core " "	100 100 100		
	23					116.9-117.8	Greenish-gray soft shale		rock core	100		
						117.8-119.1	Gray hard shale		rock core	100		
	24					119.1-121.5	Limestone lense 119.1-119.9'		rock core	90		
						121.5-124.9	Light gray limestone w/shale partings		rock core	90		
Bottom of test boring 124.9' ground water level at completion = 11.0 ft., and after 24 hours 28 ft.												
26	1,2	US 50B	45+00	CL"S-8-J"	478.0	0.0-4.0	Brown moist medium stiff clay loam	A-6(6)				Sandstone/Shale Plateau

APPENDIX A-3 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description: Texture	Soil Description: AASHTO	Blow Per Foot	Recovery %	RQD	Notes
26	3	US 50B	45+00	CL"S-8-J"	478.0	4.0-6.0	Brown moist medium dense sandy loam	A-2-4				Sandstone/Shale Plateau
	4,5,6, 7,8					6.0-16.0	Brown moist medium stiff to stiff clay gray below 9 ft.	A-6				
Bottom of test boring 16.0', groundwater level at completion 10.0 ft., after 24 hours 7.0 ft.												
27	1	US 50B	603+00	100LJ"J"	484.0	0.0-3.0	Brown moist stiff clay	A-7-6	4 6/8	75		Sandstone/Shale Plateau
	2					3.0-6.0	Brown moist stiff clay loam	A-4	4 5/7	75		
	3					6.0-8.5	Soft from 6.0-7.5 ft.	A-4	3 3/2	50		
	4					8.5-12.5	Brown moist stiff silty loam	A-4	5 6/5	100		
	5					12.5-17.5	Gray moist very stiff clay	A-6	5 7/9	60		
	6					17.5-22.5	Gray very moist stiff silty loam	A-4	4 5/8	100		
	7					22.5-30.0	Gray very moist very stiff clay w/layers of silt	A-6	7 10/13	100		
Bottom of test boring 30 ft. Hole caved to 6.0 ft.												
28	1,2 3	US 50B	623+70	80'RT"J"	491.0	0.0-8.0	Brown moist soft to medium stiff silty clay loam	A-6	2 2/2 3 3/4 1 3/3	75 60 80		Sandstone/Shale Plateau
	4					8.0-12.5	Brown to gray moist medium dense sandy loam	A-2-4	3 5/6	50		

APPENDIX A-3 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
28	5	US 50B	623+70	80'RT"J"	491.0	12.5-17.5	Gray moiat soft clay loam	A-6	2 2/2	100		Sandatone/Shale Plateau
	6					17.5-22.5	Gray moist dense sandy loam with rock fragments	A-2-4	8 12/40	100		
	7,8					22.5-32.0	Gray moist soft to medium atiff clay	A-7-6	2 3/4 2 2/3	100 100		
	9					32.0-37.0	Gray moist medium atiff clay loam	A-6	3 4/4	100		
	10,11					37.0-45.0	Gray moist hard clay loam (with few boulders)	A-4	11 12/32 4 10/27	100 75		
29	1	US 50B	710+00	42'LT"J"	475.0	0.0-3.0	Gray very moist, very ailty clay loam		2 1/1	100		Flood Plain bordered by Sandstone/Shale Plateau
	2					3.0-6.0	Brown and gray very moist soft clay	A-6	1 2/3	100		
	3,4					6.0-11.0	Gray and brown medium stiff to stiff clay loam	A-4	5 7/7 3 5/5	100 90		
	5					11.0-17.0	Brown moist medium dense sandy loam	A-2-4(0)	4 8/12	70		
	6					17.0-22.0	Gray wet loose sandy loam	A-2-4	2 3/3	100		
	7					22.0-27.0	Gray moist stiff clay	A-7-6	3 5/6	100		
	8,9					27.0-34.0	Gray moist very stiff to hard clay	A-6	3 12/13 50/6	100 100		

Bottom of test boring 34'

APPENDIX A-3 (Con't)

Boriog No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
30	1,2 3	US 50B	745+50	42'RT"K"	516.0	0.0-8.0	Brown moist dense to very dense sand with rock fragments	A-3	3 16/20 50/4 6 6/9	50 5 0		Flood Plain in Sandstone/Shale Plateau
	4,5 6					8.0-22.5	Brown moist dense sandy loam	A-2-4	20 9/6 9 9/9 15 18/20	40 50 50		
	7,8					22.5-29.0	Brown moist dense sand	A-3	8 12/19	40		
	9					29.0-30.0	Gray dry shale		50/3			
Bottom of boring. Auger refusal at 30.0'.												
31	1	US 50B	839+00	170'RT"K"	495.0	0.0-3.5	Brown moist medium stiff silty clay loam	A-6(12)	2 3/3	100		Sandstone/Shale Plsteau
	2					3.5-5.0	Brown very moist very soft sandy loam	A-2-4	1 1/1	100		
	3					5.0-8.0	Gray wet hard silty clay	A-7-6	50/3	80		
	4					8.0-9.5	Gray wet very dense sand	A-3	50/25	75		
Bottom of test boring at 9.5'. Auger refusal at 9.5'.												
32	1,2	US 50B	900+00	42'LT"K"	510.0	0.0-5.5	Gray wet very soft clay loam	A-4	1 0/0 1 2/2	50 100		
	3					5.5-7.5	Gray wet soft sandy loam	A-2-4(0)	2/2 50/5	100		
Bottom of test boring 7.5'. Auger refusal at 7.5'												

APPENDIX A-3 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
33		US 50B	1052+30	42'LT"J"	547.0	0.0-1.0	Topsoil					Sandstone/Shale Plateau and Flood Plain
	1					1.0-3.5	Brown and gray moist medium stiff silty clay loam	A-6	2 2/4	100		
	2					3.5-6.0	Brown and gray moist medium stiff clay	A-7-6	1 2/4	100		
	3,4, 5					6.0-17.5	Brown and gray moist stiff clay	A-6	4 6/8 5 5/10 4 5/7	100 100 100		
	6					17.5-21.0	Brown moist medium stiff clay	A-7-6	3 4/3	100		
	7					21.0-26.0	Brown and gray moist stiff clay	A-6(17)	3 6/10	100		LL=37; PL=19, LI=18
	8					26.0-30.0	Brown damp very stiff clay loam	A-6	5 8/9	100		
Bottom of boring 30.0'												
34	1	US 50B	619+50	110'LT"J"	529.0	0.0-3.0	Brown, moist, soft clay loam	A-6	2 2/3	80		
	2,3					3.0-7.5	Brown moist, very loose silty loam, loose 5-7.5 ft.	A-4	1 1/2 4 5/5	60 90		
						7.5-10.5	Brown moist medium stiff clay loam	A-6	2 3/4	100		
Bottom of test boring 10.0. Hole Caved in to 6.0 ft. Groundwater at completion = dry.												

APPENDIX A-3 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description: Texture	Soil Description: AASHTO	Blow Per Foot	Recovery %	RQD	Notes
35	1,2,3, 4,5,6, 7,8,9, 10	US 50B	619+50	170'LT"J"	542.0	0.0-25.3	Brown moist very loose to medium dense sandy loam	A-2-4	1 2/2 2 3/2 3 2/1 3 5/6 9 9/11 6 6/7 5 7/7 5 6/5 1 1/1 2 2/1	30 40 60 100 90 90 90 100 5 100		Sandstone/Shale Bordered by Flood Plain Sample #9 last blow drove sampler 1.5 ft. (from 22 to 23.0 ft).
	10					25.3-27.0	Brown to gray wet, medium dense silty loam	A-4	4 9/13	100		
	11					27.0-29.0	Brown to gray moist very stiff clay loam	A-4				
	12					29.0-29.8	Gray moist weathered shale					
						29.8-30.0	Coal					
Bottom of test boring 30.0 ft. Hole caved to 9.0 ft., water noted on rods at 21.0 ft. Hole dry at completion.												
36	1	US 50B	588+50	120'LT"J"	476.0	0.0-15.0	Brown moist medium stiff to stiff clay loam	A-6	4 5/7	50		Sandstone/Shale Plateau
						15.0-40.5	Brown and gray moist medium stiff to stiff clay	A-7-6		100		q_u = 1.3 tsf. γ_d = 98.4 pcf. W_n = 27.5 ε_f = 14.3% q_u = 1.14 tsf. γ_d = 112.9 W_n = 18.5

APPENDIX A-3 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
Bottom of test boring and auger refusal at 40.5. Groundwater level at completion = 18.0 ft.												
37	1,2	US 50B	785+00	250'RT"M"	498.0	0.0-5.0	Brown moist to very stiff clay loam	A-4	1 5/8 7 14/16	100 100		Flood Plain
	3,4					5.0-12.5	Brown to gray mottled moist stiff to very stiff silty clay	A-7-6	4 5/6 4 4/17	100 100		
	5,6					12.5-22.5	Brown moist very stiff silty clay loam	A-6	8 11/7 7 8/17	100 70		
	7,8					22.5-27.3	Gray slightly moist hard weathered shale with trace weathered sandstone		7 7/12 50/3	6 100		Water level after 48 hours of completion = 6.0 ft.

APPENDIX A-4.

Boring and Laboratory Data for Bridge Along County Road 60 Over Indiana Creek, Martin County, Indiana (21)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description: Texture	Soil Description: AASHTO	Blow Per Foot	Recovery %	RQD	Notes
38		CR 60	11+55	36'RT. "PR-A"	481.2	0.5-15.5						
	SS-1						Soft to medium		2 2/2	100		
	SS-2						dark brown	A-6(15)	3 2/3	75		
	SS-3						with roots		3 3/3	75		
	SS-4						from 3.0' to		3 3/3	100		
	SS-5						5.0 ft.		2 2,3	100		
	SS-6					15.5-20.0	Soft, moist dark gray clay loam	A-6(15)	2 2,3	100		pH = 4.6
	SS-7						Medium stiff to very soft					Landform type: Bedrock Bench
						20.0-33.5	Moist, dark brown to brown	A-6	4 4/4	100		
	SS-8						Silty Loam with some Sand Seams		1 1/1	100		
	SS-9					33.5-37.5	Very loose, wet, grey Sand		3 1/1	50		
	RE-1					37.5-42.5	Limestone, very low bedding planes, weathed with some sand inclusions from 39.0' to 41.0, slightly fossiliferous, fine grained, medium hard, grey.		Rock Core	80	53	Auger refusal at 37.5' Bottom of rest boring 42.5. Ground water level at completion 18.0' and after 24 hours 6.0'

APPENDIX A-4 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description Texture	AASHTO	Blow Per Foot	Recovery %	RQD	Notes
39		CR 60	11+55	33'RT. "PR-A"	481.2	0.0-0.5	Topsoil					
	ST-1					0.5-15.5	Soft to medium stiff, moist dark brown, silty loam with roots from 3.0' to 6.0'	A-6		100		qu=0.41 pcf γd=92.0 p4 Wn=27.7 ε_f=10.7%
	ST-2					15.5-20.0	Soft, moi^t, dark grey clay loam with varies of organic debris and fine sand	A-6		100		εx=10.7% qu=0.52 tsf γd=55.4 pcf
	ST-3					20.0-30.0	Medium Stiff to very soft, moist dark brown to brown silty loam with some sand seams	A-6		100		W_n=71.7 ε_f=7.1 Cc=0.27 Cr=0035
Bottom of test boring = 30.0, Ground water level at completion 18' and after 24'												
40		CR 60	11+86	13'LT "PR-A"	479.0	0-0.5	Top soil					
	SS-1 SS-2					0.5-5.0	Very loose, moist brown loam with some roots	A-4(0)	2 2/2 2 2/3	100 100		pH=6.5 Landform type
	SS-3 SS-4 SS-5					5.0-20.0	Soft to medium stiff, moist dark brown, silty loam, with tree limbs or roots from 13.5-20.0	A-6	2 2/2 1 1/2 3 3/4	100 75 30		Narrow Flood Plain

APPENDIX A-4 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description: Texture	Soil Description: AASHTO	Blow Per Foot	Recovery %	RQD	Notes
	SS-6	CR 60	11+86	13'LT "DR-A"	479.0	5.0-20.0	Soft to medium stiff, moist dark brown, silty loam, with tree limbs or roots from 13.5-20.0	A-6	3 2/2	60		
	SS-7					20.0-27.5	Medium dense, wet, light gray sandy loam	A-2-4(0)	12 13/11	100		qu=3.29 tsf γ_d=97.5 pcf
	SS-8					27.5-31.6	Stiff, moist brown clay		3 3/9	50		Wn=47.4
						31.6-36.6	Limestone very low bedding planes, slightly fossiliferons, fine-grained medium hard to hard, light gray		Rock ore	93	73	εf=2.8 pH=6.9 land form type Narrow Flood Plain
Bottom of test boring 36.6', Anger refusal at 31.6' Groundwater level at completion 8.0' and after 24 hours 4.0'												
41	SS-1 SS-2 SS-3 SS-4	CR 60	12+80	12'RT "PR-A"	481.7	0.0-0.5 0.5-12.0	Top soil (visual Soft to very soft, moist dark brown Silty Loam	A-6	2 2/2 2 2/2 1 1,2 4 2,1	50 75 50 100		Landform Type: Narrow Flood Plain

APPENDIX A-4 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
	SS-5 SS-6 SS-7					12.0-28.0	Very loose, very moist to wet grey, with trace wood fragments	A-2-4(0)	2 1,1 3 2,1 1 1,2	60 100 100		
	SS-8					28.0-33.5	Medium dense wet grey sand		12 10/18	100		
	SS-9					33.5-38.0	Stiff, moist, brown clay		5 5/6	100		
41	RC-1	CR 60	12+80	12' RT. "PR-A"	481.7	38.0-43.0	Limestone, very low bedding,planes, fine grained, slightly fossiliferous, shale seam from 48.0 to 48.4 medium hard, light grey		Rock Core	85	78	Landform type: Narrow Flood Plain Auger Refusal at 35.0 ft. Water levels at completion 11.5' and after 24 hours 8'
42		CR 60	11+20	CL "PR-A"	480.0	0.0-0.5	Topsoil					
	SS-1 SS-2 SS-3 SS-4					0.5-14.5	Soft, moist dark brown Silty Loam	A-6	4 2/2 3 2/3 2 2/2 3 2/2	75 100 50 50		
	SS-5 SS-6					14.5-19.5	Soft to medium moist, dark brown Clay Loam	A-6	2 2/2 4 6/4	100 100		

APPENDIX A-4 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
						19.5-23.5	Medium Stiff, moist dark brown silty loam		4 6/4	100		
	SS-7 SS-8					23.5-32.5	medium stiff to stiff, moist grey clay with limestone fragments		5 4/5 7 6/7	100 100		

Auger refusal and bottom of test boring at 32.5'
Ground Water level at Completion 11'

APPENDIX A-4 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
						19.5-23.5	Medium Stiff, moist dark brown silty loam		4 6/4	100		
	SS-7 SS-8					23.5-32.5	medium stiff to stiff, moist grey clay with limestone fragments		5 4/5 7 6/7	100 100		

Auger refusal and bottom of test boring at 32.5'
Ground Water level at Completion 11'

APPENDIX A-5

Boring and Laboratory Data for S.R. 450 near Trinity Springs.

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
43	1	SR 450	100+17	18'LT	496.0	0.0-2.0	Gray Moist Stiff Shaly Clay	A-7-6 #2				
						4.0-6.0	Gray Moist Stiff Shaly Clay					
				Bottom of Test Boring 10.0' Water level at Completion - dry.								
44	1 2 3	SR 450	105+00	30'RT	472.0	0.0-6.0	Brown moist medium Stiff Silty Clay Loam Soft below 3.5'	A-6	3 3/2 2 2/3	30 10		
	4 5 6.7 8,9					6.0-26.5	Brown Moist Soft Loam Very Soft below 13.5 Soft below 17.0	A-4	2 2/2 2 2/2 1 1/1 1 3/2 4 3/2	80 90 100 100 100		
						26.5-32.0	Gray wet soft silty Clay Loam	A-6	3/3 2 2/5	100 100		
	13					32.5-38.0	Mottled Gray and Brown Moist very Stiff Clay		3 7/9	80		
	14					38.0-40.0	Gray hard weathered Shale		5 35/50	90		
				Bottom of test boring => 40.0. Ground water level at completion = 13.0								
45	1 2 3 4 5	SR 450	110+50	℄	473.5	0.0-13.0	Gray moist Very Stiff Clay Stiff from 3.5-5.0 Stiff below 8.5' medium stiff below 11.0	A-7-6	5 10/11 6 6/9 6 9/11 5 5/6 3 4/5	50 70 70 75 75		

APPENDIX A-5 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
	6					13.0-65.0	Gray wet soft		13 2/3	100		Between 16.0-18.0
	7						Silty Clay Loam		2 2/3	70		W_n = 27.5%
	8						Medium Stiff from	A-6(13)	3 5/7	100		Density = 97.85 pcf
	9						16.0 - 18.0		3 4/5	90		Qu = 0.57 tsf
	10						Stiff below 21.0'		4 4/4	100		failure Strain = 12.0%
	11						Medium Stiff below		2 3/4	90		
	12						23.5		2 3/3	100		
	13						Gray wet		2 3/3	100		
	LC2						Medium Stiff					W_n = 26.5%,
	14						Silty Clay	A-6(13)	4 7/10	100		Density = 97.4 pcf
	15						Loam		3 2/2	100		
	16						Moist very stiff		2 3/6	100		
	17						below 38.0		2 4/5	100		
							wet soft from 41.0 to 42.5					
45	18	SR 450	110+150	℄	473.5	32.5-83.5	Gray moist stiff		3 5/6	100		
	19						Silty Clay Loam		4/4	100		LL = 33.0; PL = 19;
	20						Stiff from 48.5		2 4/4	100		PI = 14.0
	RC-3						to 50.0	A-6(13)	stiff			SC = 28.8%,
												Density = 97.15 pcf
												Qu = 0.81 tsf,
												failure strain = 12.0%
	21						Stiff below		4 8/7	90		
	22						58.5		3 5/8	100		
	23								4 6/6	100		
	24						Yellow stain		6/.5	100		
	25						below 83.5'		5 6/6	100		
	25								7 8/17	0		
						85.0-90.0	Brown moist hard loam	A-4	6 6/50	90		

Bottom of test boring 90.0. Ground water level after 24 hours = 15.0 ft.

APPENDIX A-6

Boring and Laboratory Data for S.R. 450 Over Indiana Creek, Martin County, Indiana (22).

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
46	1	SR 450	105+28	16'LT	472.0	0.0-0.5 0.5-3.0	Topsoil Brown moist medium stiff silty clay loam with trace gravel (fill)		3 4/5	90		
	2					3.0-5.5	Gray moist medium dense silty loam with trace gravel (fill)		3 12/14	100		
	3					5.5-12.5	Brown moist very loose silty loam with fine sand Lenses - below 8.5'		2 2/3 2 3/4	90 90		
	4 5					12.5-17.5	Brown moist very soft silty loam with sand seams		1 1/2	80		
	6 7					17.5-27.5	Gray moist to wet very soft silty loam with sand seams and trace organic matter		0 1/1	50		
	8 9					27.5-39.5	Gray moist medium stiff silty clay with trace organic matter		2 3/3 2 3/3	90 90		
	10 11	SR 450	105+28	16'LT	472.0	39.5-44.5	Brown and gray mottled moist medium stiff clay with sandstone fragments		2 3/5 5 7/10	100 100		
						44.5-47.5	Brown moist medium dense sandstone with clay					

APPENDIX A-6 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description: Texture	Soil Description: AASHTO	Blow Per Foot	Recovery %	RQD	Notes
46	12					47.5-53.0	Gray moist stiff clay with rock fragments (seams of rock fragments with clay)		5 5/6	100		Had to redrive S-12 to get sample
	13					53.0-53.3	Gray limestone chips with clay		15/50 for 0.3"	100		Filled at completion as on edge of road.
	RC-14					53.3-56.7	Gray hard limestone		rock core	97		
Bottom of test boring 56.7'. Ground water depth at completion = 9.2 feet.												
47		SR 450	106+26	21'RT	470.6	0.0-0.5	Brown moist medium stiff silty clay loam - topsoil					Landform Type:
	1 2 3					0.5-8.0	Brown moist soft silty clay loam medium stiff from 3.5-5.0'		1 2/2 1 3/3 1 2/2	60 70 80		Narrow flood plain
	4 5					8.0-14.5	Brown moist to wet very soft silty loam with sand lenses		1 1/1 1 1/2	90 90		
	6					14.5-23.0	Gray wet very loose sandy loam		0 1/1	05		
	7					23.0-27.0	Gray moist medium dense sandy loam with little gravel		3 5/8	25		Decayed wood in S-7 (1" thick), Narrow flood plain
	8					27.0-32.0	Gray moist to wet soft silty clay loam with sand seams		1 1/3	75		Decayed wood at 29.0' (1" thick)

APPENDIX A-6 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
47	9	SR 450	106+26	21'RT	470.6	32.0-37.5	Gray moist soft clay with seams of silty clay loam		3 2/3	100		Narrow flood plain
	10					37.5-42.5	Stiff silty clay loam with clay seams		3 3/3	90		
	11					42.5-49.0	Gray moist to wet soft clay with silty clay loam seams		2 2/2	100		
	12					49.0-53.0	Gray wet loose silty sand with clay seams		0 4/2	100		
	13					53.0-58.0	Gray moist soft silty clay		0 0/4	100		
	14					58.0-63.0	Brown moist stiff silty clay with rock fragments		5 5/7	100		
						63.0-67.5	Brown moist dense clay rock fragments		6 17/14	100		
	16					67.5-70.5	Gray-green moist stiff clay with rock fragments		50 for 0.3'	100		Sample 16 appear to be driving against cobble.
	17 18					70.5-78.2	Red-brown moist stiff clay with rock fragments, cobbles and boulders (very hard augering below 70.0')		50 for 0.3' 100+ for 0.2'	100 100		Flood plain Driving on sandstone cobble or sandstone layer at 73.5' Auger refusal at 78.2'
Water depth at completion 13.3'. Bottom of test boring 78.2'.												
48		SR 450	106+71	18'LT	468.8	0.0-0.5	Brown moist soft silty loam (topsoil)					Flood plain Alluvial Terrace Deposits

APPENDIX A-6 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
48	1 2 3	SR 450	106+71	18'LT	468.8	0.5-8.0	Brown moist soft to medium stiff silty clay loam		2 2/2 3 2/3 3 5/4	80 80 80		Flood Plain Alluvial terrace deposits
						8.0-12.5	Brown moist loose loam		3 3/3	70		Seams of sand and silt noted below 12.5'
						12.5-18.0	Brown and gray mottled very soft silty clay loam with sand lenses		2 1/1	80		Water noted on rods at 18.0'
	6					18.0-24.0	Gray wet very loose sandy loam		0 1/3	60		Alluvial or sandy terrace deposits
	7					24.0-27.5	Gray moist soft silt clay		2 2/2	100		
	8					27.5-32.5	Gray moist to wet medium stiff silty clay loam with sand seams and clay seams		0 4/4	100		
	9					32.5-37.5	Gray moist to wet very soft clay with silt and sand seams		1 1/1	100		
	10 11					37.5-48.5	Gray moist medium stiff clay		3 2/4 1 2/4	100 90		
	12					48.5-52.5	Gray moist to wet loose sandy loam with clay seams		1 3/3	100		
	13					52.5-56.0	Gray wet very loose fine to medium sand		0 0/5	100		Clay aeams at 54.0' to 54.5' Cobbles 55.0-56.0'

APPENDIX A-6 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description: Texture	Soil Description: AASHTO	Blow Per Foot	Recovery %	RQD	Notes
48		SR 450	106+71	18'LT	468.8	56.0-59.5	Gray loose fine to medium sand with clay seams		6 5/5	90		Alluvial terrace or Sandy terrace deposits
	15					59.5-65.0	Gray moist stiff clay with sand lenses or seams		4 6/6	100		
						65.0-69.0	Gray moist stiff clay with sand lenses or seams					
	16 17					69.0-79.0	Reddish brown and gray mottled stiff clay		4 5/6 2 4/8	100 100		
	18					79.0-81.5	Brown wet loose silty sand with sand-stone fragments		0 5/5	100		Sample 18 rods fell 8' ± for 6" penetration
						81.5-84.9	Brown wet dense coarse sand		11 8/25	100		
						84.9-85.1	Limestone chips					Auger refusal at 85.1'
Bottom of test boring 85.1' Ground water depth 24 hours after completion 15.0'												
49		SR 450	108+49	21'LT	469.0	0.0-0.5	Topsoil					
	1 2 3					0.5-8.5	Brown very moist to wet soft silty clay very soft from 3.5-5.0' with some fine sand below 6.0'		2 3/3 1 2/1 2 1/3	100 100 100		
	4					8.5-12.0	Brown very moist very soft silty clay		1 1/1	100		Layers of fine sand and silt noted throughout depth of boring

APPENDIX A-6 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
49	5 6	SR 450	108+49	21'LT	469.0	12.0-23.0	Brown moist medium stiff silty clay with thin gray silt layers very soft below 18.0'		2 3/4 2 1/1	100 100		Water noted on rods at 17.5
	7					23.0-27.0	Gray moist very soft silty loam with trace organic matter		1 1/2	100		
	8 9 10					27.0-44.0	Gray moist very soft clay with silt seams and black markings		1 1/2 1 1/2 0 0/0	100 100 100		Sandy seam at 40.0', Sample 10- Rods fell of own wt. for 2.5' (rods were dropped 20')
	11					44.0-47.5	Gray wet loose silty loam with sand seams		1 3/3	100		
	12					47.5-50.0	Gray wet soft clay		1 2/3	100		
	13					50.0-59.0	Brown-gray wet very loose fine to medium sand with layers of gray wet soft clay with black markings		3 2/3	60		Auger fill up 40'± washed out with roller bit to 53.5 ft.
	14					59.0-62.5	Brown wet very dense fine to coarse sand with some gravel and rock fragments		15 20/40	80		Layer from 59.0' to 62.6' contained boulders, cobbles, and rock fragments
	15					62.5-67.5	Brown to gray wet loose fine to coarse sand with trace clay		4 4/5	10		

APPENDIX A-6 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description: Texture	Soil Description: AASHTO	Blow Per Foot	Recovery %	RQD	Notes
49	16 17 18	SR 450	108+49	21'LT	469.0'	67.5-83.5	Gray wet, stiff clay with several thin seams of fine coarse sand occasionally containing shells and other calcareous material and trace of organic matter, medium stiff below 73.5.		0 5/6 4 3/4 3 5/5	100 100 100		Sample 16 spoon advanced from 68.5-69.0' by weight of rods.
	19					83.5-86.0	Gray wet medium dense fine sand with trace silt		11 10/17	100		
	20					86.0-93.0	Gray wet medium stiff clay		0 0/8			DS lost.
	RC-21					93.0-96.0	Gray hard limestone		rock core			
Bottom of test boring 96.0. Ground water depth at completion 19.0'												
50		SR 450	109+49	11'RT	471.7	0.0-0.5	Topsoil					Offset boring station 109+49, 21'RT due to fence and telephone line
	1 2 3 4					0.5-11.5	Brown moist stiff silty clay - brown and gray below 6.0 - medium stiff below 8.5'		5 6/8 3 5/8 3 5/8 3 3/6	100 100 100 100		
	5					11.5-18.5	Gray very moist very soft clay		2 2/1	30		
	6					18.5-23.5	Gray very moist very soft silty clay with black markings		1 0/2	80		Boulders noted at 20.5', seams of fine sand and silt noted below 23.5'

APPENDIX A-6 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
50	7 8	SR 450	109+49	11'RT	471.7	23.5-33.5	Gray wet soft silty clay with thin layers of stiff clay and fine silty sand, very soft below 28.5 ft.		0 2/3 0 1/1	80 60		Water on Rods at 33.0'
	9 10					33.5-43.5	Gray wet very loose fine silty sand with seams of silty clay		0 2 2/3	20 70		Sample #9 - no blow count. Weight of hammer advanced spoon.
	11					43.5-48.3	Gray wet medium stiff silty clay with seams of fine sand and silt		2 4/4	80		Attempted Shelby Tube from 45.0'-47.0' could not push due to Auger head.
	12 13					48.5-54.5	Gray wet soft clay with thin seams of silt and fine sand		2 2/3 0 1/9	100 100		Weight of hammer pushed spoon from 53.5-54.0'.
	14 15 16					54.5-74.6	Gray and brown wet loose fine medium sand		1 3/4 1 4/5 2 3/5	100 10 100		Large gravel, cobbles or boulders from 6.0' to 63.0'.
						74.6-79.5	Gray moist loose fine sand with clay seams		4 4/4 3 4/5	100 100		
	19 20					79.5-87.0	Gray wet stiff clay with a few thin silt lenses. Soft below 83.5'		3 4/6 0 0/4	100 100		Rods fell of own weight in the first 1.0 of Sample 20.

APPENDIX A-6 (Con't)

Boring No	Sample No	Highway Route No	Station No	Offset Ft	Ground Elevation (ft.)	Sample Depth (ft.)	Soil Description		Blow Per Foot	Recovery %	RQD	Notes
							Texture	AASHTO				
50	21	SR 450	109+49	11'RT	471.7	89.5-91.0	Gray limestone chips with soil binder		0 6/14	100		Rods fell of own weight in frost 6" of Sample 21. 6" clay seam from BB.5' to 89.0' Auger refussl at 91.0'.

Bottom of test boring 91.0'. Coved to 15.0' at completion. Groundwater depth at completion 15.0 ft., after 24 hours, dry.

APPENDIX B

Appendix B.
Engineering Properties of Agricultural Soils of Martin County.

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification USCS	Classification AASHTO	Frags > 3in (%)	Percent Passing Sieve # #4	#10	#40	#200	LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Permeability (in/hr)	Soil React. (pH)	Shrink/Swell Potential
Abscota	0-13	Loamy Sand	SM,SP-SM	A-2-4 A-3	0	95-100	95-100	50-75	15-30	---	NP	0-15	1.20-1.60	6.0-20	6.1-7.8	Low
Flood Plain	13-60	Loamy Sand, Fine Sand	SP,SM, SP-SM	A-2-4, A-1,A-3	0	95-100	95-100	45-75	3-30	<2	NP	0-15	1.20-1.60	6.0-20	6.1-8.4	Low
Alvin	0-12	Loamy Fine Sand	SM	A-2	0	100	100	50-75	15-30	<20	NP-4	5-10	1.50-1.70	6.0-20	5.1-6.5	Low
Windblown Sand on Terrace	12-70	Very Fine Sandy Loam, Sandy Loam, Sandy Clay Loam	SM,SC, CL, ML	A-2,A-4, A-6	0	100	100	90-100	20-80	15-38	NP-13	15-18	1.45-1.65	0.6-6.0	4.5-6.5	Low
	70-80	Stratified Sandy Loam to Fine Sand	SM, SP SP-SM	A-2,A-3	0-5	95-100	90-100	70-95	4-35	<20	NP-4	3-10	1.55-1.75	2.0-6.0	5.1-7.8	Low
Chelsea	0-2	Loamy Fine Sand, Fine Sand	SM, SP-SM	A-2-4	0	100	100	65-80	10-35	---	NP	8-15	1.5-1.55	6.2-20	5.6-7.3	Low
Sand Dune	20-80	Fine Sand, Sand, Loamy Sand	SP, SM, SP-SM	A-3, A-2-4	0	100	100	65-80	3-15	---	NP	5-10	1.55-1.70	6.2-20	5.1-5.5	Low

Appendix B (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification USCS	AASHTO	Frags > 3in (%)	Percent Passing Sieve # #4	#10	#40	#200	LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Permeability (in/hr)	Soil React. (pH)	Shrink/Swell Potential
Alvin	0-12	Loamy Fine Sand	SM	A-2	0	100	100	50-75	15-30	<20	NP-4	0-12	1.5-1.70			
Windblown Sand on Terrace	12-72	Very Fine Sandy Loam, Sandy Clay Loam, Loamy Fine Sand	SM, SC CL, ML	A-2, A-4 A-6	0	100	100	65-100	20-80	15-38	NP-13	12-72	1.50-1.70 1.45-1.65	6.0-20 0.6-6.0	5.1-6.5 4.5-6.5	Low Low
	72-80	Stratified Sandy Loam to Fine Sand	SM, SP SP-SM	A-2, A-3	0-5	95-100	90-100	70-95	4-35	<20	NP-4	72-80	1.55-1.75	2.0-6.0	5.1-7.8	Low
Chelsea	0-29	Loamy Fine Sand	SM, SP-SM	A-2-4	0	100	100	65-80	10-35	---	NP	8-15	1.5-1.55	6.0-20	5.6-7.3	Low
	29-80	Fine Sand, Sand, Loamy Sand	SP, SM, SP-SM	A-3, A-2-4	0	100	100	65-80	3-5	---	NP	5-10	1.55-1.70	6.0-20	5.1-5.5	Low
	0-10	Silt Loam	CL, CL-ML	A-4, A-6	0	100	100	85-100	65-90	20-35	5-15		1.30-1.45	0.6-2.0	5.1-7.3	Low
Bartle Benchlike Flats Lacustrine	10-24	Silt Loam, Silty Clay Loam	CL, CL-ML	A-4, A-6	0	100	100	90-100	70-90	25-35	5-15		1.40-1.60	0.6-2.0	4.5-5.5	Low

Appendix B (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification		Frags > 3in (%)	Percent Passing Sieve #				LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Perme-ability (In/hr)	Soil React. (pH)	Shrink/Swell Potential
			USCS	AASHTO		#4	#10	#40	#200							
	24-53	Silt Loam, Silty Clay Loam	CL	A-6, A-7	0	100	100	90-100	70-95	30-45	10-25		1.60-1.80	<0.06	4.5-5.5	Low
	53-80	Silty Clay Loam, Silt Loam	CL	A-6, A-7	0	100	100	90-100	70-95	30-45	10-25		1.40-1.60	0.2-0.6	5.1-7.3	Low
	0-6	Silt Loam	CL	A-4, A-6	0	100	95-100	90-100	80-100	24-34	8-15	15-24	1.2-1.40	0.2-0.6	5.6-7.8	Low
Birds	6-60	Silt Loam	CL	A-4, A-6	0	100	95-100	90-100	80-100	24-34	8-15	18-27	1.4-1.60	0.2-0.6	5.1-7.8	Low
Flood Plain	0-9	Silt Loam	CL	A-4, A-6	0	100	100	95-100	90-100	27-34	8-12	18-27	1.2-1.4	0.6-2.0	4.5-7.3	Low
Bonnie	9-60	Silt Loam	CL	A-4, A-6	0	100	100	95-100	90-100	27-34	8-12	18-27	1.4-1.6	0.2-0.6	4.5-5.5	Low
	0-16	Loam	ML, CL	A-4	0-10	100	100	80-95	75-95	20-35	2-10		1.2-1.40	0.6-2.0	4.5-6.0	Low
Burnside	16-42	Flaggy Sandy Loam	SC, GC, SM, GM	A-2, A-4	10-60	35-80	30-60	30-50	26-45	<20	NP-10		1.40-1.60	0.6-2.0	5.6-7.3	Low
	42	Unweathered Bedrock	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Camden	0-10	Silt Loam	CL, ML CL-ML	A-4, A-6	0	100	100	95-100	90-100	20-35	3-15	14-27	1.15-1.35	0.6-2.0	5.0-7.3	Low
Outwash Terrace	10-33	Silt Loam, Silty Clay Loam	CL	A-6	0	100	100	95-100	90-100	25-40	15-25	22-35	1.35-1.55	0.6-2.0	5.1-7.3	Moderate

Appendix 8 (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification USCS	Classification AASHTO	Frags > 3in (%)	Percent Passing Sieve # #4	#10	#40	#200	LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Perme-ability (in/hr)	Soil React. (pH)	Shrink/Swell Potential
Camden	33-62	Clay Loam, Silt Loam	ML, SC	A-2, A-4	0-5	90-100	85-100	60-95	30-90	20-40	3-15	18-30	1.45-1.65	0.6-2.0	5.6-7.3	Low
	62-80	Strat-ified Sandy Loam to Silt Loam	ML, CL	A-2, A-4	0-5	90-100	80-100	50-80	20-60	<25	3-10	5-20	1.55-1.75	0.6-2.0	5.6-8.4	Low
	0-7	Silt Loam	ML, CL	A-4, A-6	0	100	100	90-100	80-100	25-40	3-16	15-25	1.3-1.50	0.6-2.0	4.5-7.3	Low
Cincinnati	7-23	Silty Clay Loam, Loam, Silt	CL	A-6, A-4	0	95-100	90-100	90-100	70-100	25-40	8-15	22-35	1.45-1.65	0.6-2.0	4.5-7.3	Low
Illinoian Ground Moraine (Till Plain)	23-80	Loam										24-25	1.65-1.85	0.06-0.6	4.5-6.5	Moderate
	0-8	Silt Loam	ML, CL	A-4, A-6	0	100	95-100	90-100	85-100	25-35	4-12	15-27	1.20-1.40	0.6-2.0	5.1-7.3	Low
Crider Limestone Benches	8-37	Silt Loam, Silty Clay Loam	CL, ML, CL-ML	A-7, A-6, A-4	0	100	95-100	90-100	85-100	25-42	4-20	18-35	1.20-1.45	0.6-2.0	5.1-7.3	Low
	37-80	Silty Clay, Clay, Silty Clay Loam	CL, CH	A-7, A-6	0-5	85-100	75-100	70-100	60-100	35-65	15-40	30-60	1.20-1.55	0.6-2.0	4.5-6.5	Moderate

Appendix B (Con't)

Soil Name and Map Symbol	Depth (In)	USDA Text	Classification USCS	AASHTO	Frags > 3In (%)	Percent Passing Sieve # #4	#10	#40	#200	LL %	PI %	Clay (%)	Wet Density (g/cm³)	Perme-ability (In/hr)	Soil React. (pH)	Shrink/Swell Potential
Faripoint Sandstone Shale (Wabash Lowland) Plateau	0-6	Shaly Silt loam	CL, CL-ML, SC, GC	A-4, A-6, A-2	5-15	55-90	45-85	40-85	30-75	20-40	4-18	0-6	1.40-1.55	0.6-2.0	5.6-7.3	Low
	6-60	Gravelly Clay loam, Very Shaly Silty Clay loam	GC, CL, CL-ML, SC	A-4, A-6, A-7, A-2	15-30	55-75	25-65	20-65	15-60	25-50	4-24	6-60	1.60-1.80	0.6-2.0	5.6-7.3	Moderate
Hagerstown Loess on Sandstone-Shale-Limestone Plateau	0-13	Silt loam	CL, CL-ML	A-4, A-6, A-7	0-15	85-100	80-100	80-100	70-95	25-50	5-25		1.20-1.40	0.6-6.0	4.5-6.5	Low
	13-60	Clay, Silty Clay, Silty Clay Loam	CH, CL	A-7, A-6	0-5	85-100	80-100	75-100	75-95	30-70	15-40		1.20-1.6	0.6-2.0	5.1-7.3	Moderate
Haymond Flood Plain	0-9	Silt loam	ML	A-4	0	100	100	90-100	80-90	27-36	4-10	10-18	1.30-1.45	0.6-2.0	5.6-7.3	Low
	9-59	Silt loam	ML	A-4	0	100	100	90-100	80-90	27-36	4-10	0-18	1.30-1.45	0.6-2.0	5.6-7.3	Low
	59-70	Fine Sandy loam, Silt loam, loam	ML, SM	A-4	0	95-100	90-100	80-100	35-90	27-36	4-10	10-18	1.30-1.45	0.6-2.0	6.1-7.8	Low
Hosmer Loess on Lacustrine Plain	0-8	Silt loam	ML, CL-ML, CL	A-4	0	100	100	90-100	70-90	<25	3-10	10-17	1.20-1.40	0.6-2.0	4.5-7.3	Low

Appendix B (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification USCS	Classification AASHTO	Frags > 3in (%)	Percent Passing Sieve # #4	#10	#40	#200	LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Perme-ability (in/hr)	Soil React. (pH)	Shrink/Swell Potential
Hosmer	8-26	Silt loam, Silty Clay loam	CL, CL-ML, ML	A-4, A-6	0	100	100	90-100	70-95	25-35	5-15	24-30	1.30-1.50	0.6-2.0	4.5-5.5	Moderate
	26-80	Silt loam, Silty Clay	CL, CL-ML, ML	A-4, A-6	0	100	100	90-100	70-95	20-55	30	16-42	1.6-1.70	<0.06	4.0-6.0	Low
Johnsburg	0-13	Silt loam	CL, ML	A-4, A-6	0	100	100	90-100	70-95	30-40	5-15	12-20	1.30-1.45	0.6-2.0	4.5-7.3	Low
Loess on Lacustrine Plains	13-23	Silty Clay loam, Silt loam	CL	A-6, A-7	0	100	100	95-100	85-95	35-50	20-30	24-32	1.40-1.55	0.6-2.0	3.6-5.5	Moderate
	23-42	Loam, Silt loam, Silty Clay loam	CL, CL-ML	A-4, A-6	0-5	95-100	90-95	85-95	60-85	20-35	5-15	22-30	1.60-1.80	<0.06	3.6-5.5	Low
	42-70	Loam, Sandy loam, Silt loam	CL, SC, CL-ML, SM-SC	A-4, A-6	0-10	90-95	85-90	60-90	35-70	20-30	5-15	14-20	1.40-1.55	0.6-2.0	3.6-5.5	Low
Markland	0-5	Silt loam	CL, CL-ML	A-4, A-6	0	100	100	90-100	70-90	25-35	5-15	20-27	1.30-1.45	0.6-2.0	51.-7.3	Low
Lacustrine Plain and Terrace	5-35	Silty Clay, Clay, Silty Clay loam	CL, CH	A-7	0	100	100	95-100	95-95	45-60	19-32	40-55	1.55-1.70	0.06-2.0	5.1-8.4	High

Appendix B (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification		Frags > 3in (%)	Percent Passing Sieve #				LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Permeability (in/hr)	Soil React. (pH)	Shrink/Swell Potential
			USCS	AASHTO		#4	#10	#40	#200							
	35-60	Stratified Clay to Silty Clay Loam	CL, CH, ML, MH	A-7	0	100	100	90-100	75-95	40-55	15-25	30-50	1.55-1.70	0.06-0.2	7.4-8.4	High
Markland	0-3	Silty Clay Loam	CL	A-6, A-7	0	100	100	95-100	85-95	30-45	10-20	28-40	1.35-1.50	0.2-0.6	5.1-7.3	Moderate
Lacustrine Plain and Terrace	3-27	Silty Clay, Clay, Silty Clay Loam	CL, CH	A-7	0	100	100	95-100	90-95	45-60	19-32	40-55	1.55-1.70	0.06-0.2	5.1-7.3	High
	27-60	Stratified Clay to Silty Clay Loam	CL, CH ML, MH	A-7	0	100	100	90-100	75-95	40-55	15-25	35-50	1.55-1.70	0.06-0.2	7.4-8.4	High
Martinsville	0-9	Loam	CL, CL-ML, ML	A-4	0	100	85-100	75-100	65-90	<25	3-8	8-20	1.3-1.45	0.6-2.0	5.1-7.3	Low
Alluvial Terrace (Sand and Gravel)	9-58	Fine Sandy loam, loam, Sandy Clay loam	SM-SC, CL-ML, CL-SC	A-2, A-4 A-6	0	95-100	85-100	55-95	30-75	20-30	5-11	15-25	1.40-1.60	0.6-2.0	5.1-6.5	Low
	58-80	Stratified Sand to	SM, SM-SC, CL-ML	A-4, A-2-4,	0	95-100	85-100	45-95	10-75	<25	NP-8	2-20	1.5-1.70	0.6-6.0	5.6-8.4	Low

Appendix B (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification		Frags > 3in (%)	Percent Passing Sieve #				LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Permeability (in/hr)	Soil React. (pH)	Shrink/Swell Potential
			USCS	AASHTO		#4	#10	#40	#200							
McGary	0-7	Silty Clay Loam	CL	A-6,A-7	0	100	100	90-100	70-95	30-45	15-25	27-40	1.40-1.60	0.2-0.6	6.6-7.3	High
Lacustrine Terrace	7-60	Silty Clay, Silty Clay loam	CL,CH	A-7	0	100	100	95-100	90-100	46-58	24-32	35-50	1.60-1.75	0.06-0.2	5.6-7.8	Moderate
Negley	0-9	Silt loam, loam	ML,CL-ML, CL	A-4,A-6	0	85-100	75-100	70-90	55-85	25-40	4-15	12-27	1.30-1.50	2.0-6.0	4.5-7.3	Low
Outwash Plain and Terrace	9-80	Loam, Clay loam, Gravelly Sandy loam	SM,ML	A-4,A-2 A-6,A-7	0-5	70-95	50-90	35-80	20-60	25-45	3-17	18-35	1.30-1.60	0.6-6.0	4.5-6.5	Low
Newark	0-13	Silt loam	ML,CL, CL-ML	A-4	0	95-100	90-100	80-100	55-95	<32	NP-10	7-27	1.20-1.40	0.6-2.0	5.6-7.8	Low
Flood Plain	13-32	Silt loam, Silty Clay loam	ML,CL CL-ML	A-4,A-6, A-7	0	95-100	90-100	85-100	70-98	22-42	3-20	18-35	1.20-1.45	0.6-2.0	5.6-7.8	Low
	32-60	Silt loam, Silty Clay loam	ML,CL, CL-ML	A-4,A-6, A-7	0-3	75-100	70-100	65-100	55-95	22-42	3-20	12-40	1.30-1.50	0.6-2.0	5.6-7.8	Low
Nolin Flood Plain	0-11	Silt loam	ML,CL, CL-ML	A-4,A-6	0	100	95-100	90-100	80-100	25-40	5-18	12-35	1.20-1.40	0.6-2.0	5.6-8.4	Low

Appendix B (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification		Frags > 3in (%)	Percent Passing Sieve #				LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Permeability (in/hr)	Soil React. (pH)	Shrink/Swell Potential
			USCS	AASHTO		#4	#10	#40	#200							
	11-70	Silt loam, Silty Clay loam	ML, CL, CL-ML	A-4, A-6 A-7	0	100	95-100	85-100	75-100	25-46	5-23	18-35	1.25-1.50	0.6-2.0	5.6-8.4	Low
Parke	0-6	Silt Loam	CL-ML, CL	A-4, A-6	0	100	100	90-100	70-100	20-35	7-15	18-27	1.25-1.40	0.6-2.0	5.1-6.5	Low
Loess on Outwash Terrace	6-34	Silty Clay loam, Silt loam	CL	A-6, A-4	0	95-100	95-100	90-100	80-100	25-40	7-15	22-32	1.3-1.45	0.6-2.0	4.5-6.0	Moderate
	34-80	Sandy Clay loam, Silty Clay	SC, CL	A-2, A-6 A-4	0-3	90-100	85-95	55-90	30-60	25-35	7-15	18-30	1.55-1.65	0.6-2.0	4.5-5.5	Low
Alluvial Terrace (Low Terraces)	0-12	Silt loam	CL, CL-ML	A-4, A-6	0	100	100	85-100	65-100	20-30	5-15	15-26	1.30-1.45	0.6-2.0	5.6-7.3	Low
	12-24	Silt loam, Silty Clay loam	CL	A-6	0	100	100	90-100	70-100	25-40	10-20	25-35	1.40-1.60	0.6-2.0	4.5-5.5	Low
	24-58	Silt loam, Silty Clay loam	CL, CL-ML	A-4, A-6	0	100	100	88-98	65-90	25-35	5-15	22-30	1.60-1.80	<0.06	4.5-5.5	Low
	58-70	Stratified fine Sandy loam to Silty Clay loam	CL, CL-ML	A-4, A-6	0	100	100	80-95	50-85	20-40	5-15	20-34	1.40-1.60	0.6-2.0	4.5-7.3	Low

Appendix B (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification		Frags > 3in (%)	Percent Passing Sieve #				LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Perme-ability (in/hr)	Soil React. (pH)	Shrink/Swell Potential
			USCS	AASHTO		#4	#10	#40	#200							
	0-14	Silt loam	CL	A-4,A-6	0	100	100	90-100	80-95	25-35	8-15	18-27	1.25-1.40	0.6-2.0	5.1-7.3	Low
Loess on Outwash Terrace	14-42	Silty Clay loam, Silt loam	CL	A-6,A-7	0	100	95-100	85-100	80-90	30-45	10-25	22-35	1.30-1.45	0.6-2.0	4.5-5.5	Low
	42-80	Loam, Silt loam, Sandy Clay loam	CL,SC	A-6, A-2-6	0	80-100	70-100	60-95	30-80	20-35	10-20	18-35	1.30-1.45	0.6-2.0	4.5-5.5	Low
Wakeland	0-7	Silt loam	ML	A-4	0	100	100	90-100	80-90	27-36	4-10	10-17	1.30-1.50	0.6-2.0	5.6-7.3	Low
Flood Plain	7-60	Silt loam	ML	A-4	0	100	100	90-100	80-90	27-36	4-10	10-17	1.30-1.50	0.6-2.0	5.6-7.3	Low
Wellston	0-6	Silt loam	ML	A-4	0	95-100	90-100	85-100	70-95	25-35	3-10	13-77	1.3-1.5	0.6-2.0	5.1-6.5	Low
Sandstone Shale Plateau	6-48	Silt loam, Silty Clay	CL,CL-ML	A-6,A-4	0-5	75-100	70-100	60-95	60-90	25-40	6-70	18-35	1.3-1.60	0.6-2.0	4.5-6.0	Low
Gilpin Sandstone Shale Plateau	0-4	Channery silt loam	GC,SC	A-2,A-4	0-30	50-90	45-85	35-75	30-70	20-40	4-15	15-27	1.2-1.4	0.6-2.0	3.6-5.5	Low

Appendix B (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification		Frags > 3in (%)	Percent Passing Sieve #				LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Permeability (in/hr)	Soil React. (pH)	Shrink/Swell Potential
			USCS	AASHTO		#4	#10	#40	#200							
	4-30	Channery Silt loam, Shaly Silt loam, Channery Silty Clay loam	GC, SC, CL, CL-ML	A-2, A-4, A-6	0-30	50-95	45-90	35-85	30-80	20-40	4-15	18-35	1.2-1.5	0.6-2.0	3.6-5.5	Low
	30-36	Unweathered bedrock	--	--	--	--	--	--	--	--	--	15-35	1.2-1.5	0.6-2.0	3.6-5.5	Low
Wellston	0-12	Silt loam	ML	A-4	0	95-100	90-100	85-100	70-95	25-35	3-10	13-27	1.3-1.50	0.6-2.0	5.1-6.5	Low
Sandstone Shale Plateau	12-36	Silt loam, Silty Clay loam	CL, CL-ML	A-6, A-4	0-5	75-100	70-100	60-95	60-90	25-40	5-20	18-35	1.3-1.65	0.6-2.0	4.5-6.0	Low
	36-60	Silt loam, loam, Channery loam	CL-ML, CL, GC, SM-SC	A-4, A-6	0-10	65-90	65-90	60-90	40-65	20-35	5-15	15-30	1.30-1.60	0.6-2.0	4.5-6.0	Low
Ebal	0-5	Silt loam	CL-ML, CL	A-4, A-6	0	95-100	95-100	85-100	70-90	25-35	5-15	20-28	1.35-1.50	0.6-2.0	4.5-6.0	Low
Sandstone Shale Plateau	5-24	Channery Silty Clay, very Channery Clay	CL, CH GC	A-7	3-15	60-70	50-70	45-70	40-65	40-55	20-30	38-50	1.45-1.65	0.2-0.6	4.5-6.0	Moderate

Appendix B (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification		Frags > 3in (%)	Percent Passing Sieve #				LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Permeability (in/hr)	Soil React. (pH)	Shrink/Swell Potential
			USCS	AASHTO		#4	#10	#40	#200							
	24-70	Clay	CH	A-7	0-3	95-100	70-100	55-100	55-95	60-75	35-45	55-70	1.55-1.75	<0.06	4.5-6.0	High
Wellston	0-6	Silt loam	ML	A-4	0	95-100	90-100	85-100	70-95	25-35	3-10	12-27	1.30-1.50	0.6-2.0	5.1-6.5	Low
Sandstone Shale Plateau	6-49	Silt loam, Silty Clay loam	CL, CL-ML	A-6,A-4	0-5	75-100	70-100	60-95	60-90	25-40	5-20	18-35	1.30-1.65	0.6-2.0	4.5-6.0	Low
	49-60	Silt loam, Channery loam	SC,SM-SC	A-4,A-6	0-10	65-90	65-90	60-90	40-65	20-35	5-15	13-50	1.30-1.60	0.6-2.0	4.5-6.0	Low
Gilpin	0-4	Channery Silt loam	GC,SC, CL,CL-ML	A-2,A-4, A-6	0-30	50-90	45-85	35-75	30-70	20-40	4-15	15-27	1.2-1.4	0.6-2.0	3.6-5.5	Low
Sandstone Shale Plateau	4-31	Channery loam Shaley Silty Clay loam, Silty Clay loam	GC,SC, CL,CL-ML	A-2,A-4, A-6	0-30	50-95	45-90	35-85	30-80	20-40	4-15	18-35	1.2-1.5	0.6-2.0	3.6-5.5	Low
	31-39	Channery loam very Channery Silt loam, very Shaley Silty Clay loam	GC,GM-GC	A-1,A-2, A-4,A-6	0-35	25-55	20-50	15-45	15-40	20-40	4-15	15-35	1.2-1.5	0.6-2.0	3.6-5.5	Low

Appendix B (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification USCS	AASHTO	Frags > 3in (%)	Percent Passing Sieve # #4	#10	#40	#200	LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Permeability (in/hr)	Soil React. (pH)	Shrink/Swell Potential
	39	Unweathered bedrock	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Wellston	0-1	Silt loam	ML	A-4	0	95-100	90-100	85-100	70-95	25-35	3-10	13-27	1.3-1.5	0.6-2.0	5.1-6.5	Low
Sandstone Shale Plateau	1-39	Silt loam, Silty Clay loam	CL, CL-ML	A-6, A-4	0-5	75-100	70-100	60-95	60-90	25-40	5-20	18-35	1.3-1.65	0.6-2.0	4.5-6.0	Low
	39-55	Silt loam, Loam, Channery loam	CL-ML, CL, SC, SM-SC	A-4, A-6	0-10	65-90	65-90	60-90	40-65	20-35	5-15	15-30	1.3-1.60	0.6-2.0	4.5-6.0	Low
	55	Unweathered bedrock	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Wirt	0-6	Silt loam	ML, CL-ML	A-4	0	100	100	90-100	70-90	<25	3-7	10-17	1.30-1.45	0.6-2.0	5.6-7.3	Low
Flood Plain	6-60	Silt loam	ML, CL-ML	A-4	0	100	100						1.30-1.45	0.6-2.0	5.6-7.3	Low
Wirt	0-6	Fine Sandy loam	SM, SM-SC, ML, CL-ML	A-4	0	95-100	90-100	65-85	35-55	<25	NP-6	8-16	1.35-1.50	0.6-2.0	5.6-7.3	Low
Flood Plain	6-60	Silt loam, Fine Sandy loam	CL-ML, ML	A-4	0	95-100	90-100	75-100	55-90	<25	3-7	10-18	1.40-1.55	0.6-2.0	5.6-7.3	Low

Appendix B (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification USCS	AASHTO	Frags > 3in (%)	Percent Passing Sieve # #4	#10	#40	#200	LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Permeability (in/hr)	Soil React. (pH)	Shrink/Swell Potential
Zanesville	0-5	Silt loam	CL-ML, CL,ML	A-4,A-6	0	95-100	95-100	90-100	80-100	25-40	4-15	12-27	1.35-1.40	0.6-2.0	4.5-5.5	Low
Sandstone Shale Plateau	5-30	Silt loam, Silty Clay loam	CL,CL-ML	A-4,A-6	0	95-100	95-100	90-100	80-100	25-40	5-20	18-35	1.35-1.45	0.6-2.0	4.5-5.5	Low
	30-44	Silt loam, Silty Clay loam	ML,CL CL-ML	A-4,A-6	0-3	90-100	85-100	80-100	60-100	20-40	2-20	18-33	1.50-1.75	0.06-0.2	4.0-5.5	Low
	44-60	Sandy Clay loam, Clay loam, Channery loam	SC,CL, SM, GM	A-6,A-4, A-2, A-1-B	0-10	65-100	50-100	40-100	20-85	20-40	2-20	20-24	1.50-1.70	0.2-2.0	4.0-5.5	Low
Zanesville	0-1	Silt loam	CL-ML, CL,ML	A-4,A-6	0	95-100	95-100	90-100	80-100	25-40	4-15	12-27	1.35-1.40	0.6-2.0	4.5-5.5	Low
Sandstone Shale Plateau	1-20	Silt loam, Silty Clay loam	CL,CL-ML	A-4,A-6	0	95-100	95-100	90-100	80-100	25-40	5-20	18-35	1.50-1.70	0.06-2.0	4.5-5.5	Low
	20-39	Silt loam, Silty Clay loam	ML,CL CL-ML	A-4,A-6	0-3	90-100	85-100	80-100	60-100	20-40	2-20	18-33	1.5-1.70	0.06-0.2	4.5-5.5	Low

Appendix B (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification		Frags > 3in (%)	Percent Passing Sieve #				LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Perme-ability (in/hr)	Soil React. (pH)	Shrink/Swell Potential
			USCS	AASHTO		#4	#10	#40	#200							
	39-70	Sandy Clay loam, Clay loam, Channery loam	SC,CL, SM,GM	A-6,A-4 A-2, A-1-B	0-10	65-100	50-100	40-100	20-85	20-40	2-20	20-24	1.5-1.70	0.2-2.0	4.5-5.5	Low
Zanesville Sandstone Shale Plateau	0-1	Silt loam	CL-ML, CL,ML	A-4,A-6	0	95-100	95-100	90-100	80-100	25-40	4-15	12-27	1.35-1.40	0.6-2.0	4.5-5.5	Low
	1-30	Silt loam, Silty Clay loam	CL,CL-ML	A-4,A-6	0	95-100	95-100	90-100	80-100	25-40	5-20	18-35	1.30-1.45	0.6-2.0	4.5-5.5	Low
	30-48	Silt loam, Silty Clay loam	ML,CL, CL-ML	A-4,A-6	0-3	90-100	85-100	80-100	60-100	20-40	2-20	18-33	1.50-1.75	0.06-0.2	4.5-5.5	Low
	48-55	Sandy Clay loam, Clay loam	SC,CL, SM,GM	A-6,A-4, A-2, A-1-B	0-10	65-100	50-100	40-100	20-85	20-40	2-20	20-40	1.5-1.70	0.2-2.0	4.5-5.5	Low
	55	Unweathered bedrock	--	—	--	--	--	--	--	--	--	--	--	--	--	--

Appendix B (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification		Frags > 3in (%)	Percent Passing Sieve #				LL %	PI %	Clay (%)	Wet Density (g/cm^3)	Perme-ability (in/hr)	Soil React. (pH)	Shrink/Swell Potential
			USCS	AASHTO		#4	#10	#40	#200							
Zipp Lacustrine Plain	0-10	Silty Clay loam	CL	A-6,A-7	0	100	100	95-100	90-95	35-50	15-25	22-40	1.40-1.60	0.2-0.6	6.1-7.3	Moderate
	10-47	Silty Clay	CL,CH	A-7	0	100	100	95-100	90-95	45-60	25-35	40-55	1.45-1.70	0.06-0.2	6.1-7.3	High
	47-60	Silty Clay	CL,CH	A-7	0	100	100	90-100	75-95	45-60	25-35	36-55	1.5-1.70	0.06-2.0	6.1-7.8	High

APPENDIX C

Appendix C.
Engineering Properties of Agricultural Soils and Rating of Predominant Soil Conditions of Martin County

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification USCS	Classification AASHTO	Frag > 3in (%)	Percent Passing Sieve # #4	#10	#40	#200	LL (%)	PI (%)	Clay (%)	Rating of Predominant Soil Conditions Roadfill	Sand	Gravel	Topsoil
Abscota	0-13	Loamy Sand	SM, SP-SM	A-2-4 A-3	0	95-100	95-100	50-75	15-30	--	NP	0-15	Good	Proba-ble	Improba-ble: too sandy	Poor: too sandy
Flood Plain	13-60	Loamy sand, fine sand	SP, SM, SP-SM	A-2-4, A-1, A-3	0	95-100	95-100	45-75	3-30	<2	NP	0-15				
Alvin	0-12	Loamy fine sand	SM	A-2	0	100	100	50-75	15-30	<20	NP-4	5-10				
Windblown Sand on Terrace	12-70	Very fine sandy loam, sandy loam, sandy clay loam	SM, SC CL, ML	A-2, A-4,	0	100	100	90-100	20-80	15-38	NP-13	15-18	Good	Proba-ble	Improba-ble: too sandy	Fair: too sandy
	70-80	Stratified sandy loam to fine sand	SM, SP SP-SM	A-2, A-3	0-5	95-100	90-100	70-95	4-35	<20	NP-4	3-10				
Chelsea	0-20	Loamy fine sand, fine sand	SM, SP-SM	A-2-4	0	100	100	65-80	10-35	--	NP	8-15	Good	Proba-ble	Improba-ble: too sandy	Poor: Slope
Sand Dune	20-80	Fine sand, sand, loamy sand	SP, SM,	A-3, A-2-4	0	100	100	65-80	3-15	--	NP	5-10				
Alvin	0-12	Loamy fine sand	SM	A-2	0	100	100	50-75	15-30	<20	NP-4	0-12	Poor: Slope	Proba-ble	Improba-ble: too sandy	Poor: Slope
Windblown sand on terrace	12-72	Very fine sandy loam, sandy clay loam Loamy fine sand	SM, SC CL, ML	A-2, A-4, A-6	0	100	100	65-100	20-80	15-38	NP-13	12-12				
	72-80	Stratified sandy loam to fine sand	SM, SP SP-SM	A-2, A-3	0-5	95-100	90-100	70-95	4-35	<20	NP-4	72-80				
Chelsea	0-29	Loamy fine sand	SM, SP-SM	A-2-4	0	100	100	65-80	10-35	--	NP	8-15	Poor: Slope	Proba-ble	Improba-ble: too sandy	Poor: Slope
	29-80	Fine sand, sand, loamy sand	SP, SM, SP-SM	A-3, A-2-4	0	100	100	65-80	3-5	--	NP	5-10				

Appendix C (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification		Frag > 3in (%)	Percent Passing Sieve #				LL (%)	PI (%)	Clay (%)	Rating of Predominant Soil Conditions			
			USCS	AASHTO		#4	#10	#40	#200				Roadfill	Sand	Gravel	Topsoil
Bartle	0-10	Silt loam	CL,CL-ML	A-4,A-6	0	100	100	85-100	65-90	20-35	5-15		Poor: low strength	Improba-ble access fines	Improba-ble access fines	Good
Benchlike flats Lacustrine	10-24	Silt loam, silty clay loam	CL,CL-ML	A-4,A-6	0	100	100	90-100	70-90	25-35	5-15					
	24-53	Silt loam, silty clay loam	CL	A-6,A-7	0	100	100	90-100	70-95	30-45	10-25					
	53-80	Silty clay loam, silt loam	CL	A-6,A-7	0	100	100	90-100	70-95	30-45	10-25					
Birds	0-6	Silt loam	CL	A-4,A-6	0	100	95-100	90-100	80-100	24-34	8-15		Poor: low strength wetness	Improba-ble: access fines	Improba-ble: access fines	Poor: wetness
Flood Plain	6-60	Silt loam	CL	A-4,A-6	0	100	95-100	90-100	80-100	24-34	8-15					
Bonnie	0-9	Silt loam	CL	A-4,A-6	0	100	100	95-100	90-100	27-34	8-12	18-27	Poor: low strength wetness	Improba-ble excess fines	Improba-ble access fines	Poor: wetness
Flood Plain	9-60	Silt loam	CL	A-4,A-6	0	100	100	95-100	90-100	27-34	8-12	18-27				
Burnside	0-16	Loam	ML,CL	A-4	0-10	100	100	80-95	75-95	20-35	2-10		Fair: depth to rock, thin layer large stones	Improba-ble: excess fines, large stones	Improba-ble: excess fines large stones	Poor: small stones area reclaim
Flood Plain	16-42	Flaggy Sandy loam	SC,GC, SM,GM	A-3,A-4	10-60	35-80	30-60	30-50	26-45	<20	NP-10					
	42	Unweakened bedrock	--	--	--	--	--	--	--	--	--					
Camden	0-10	Silt loam	CL,ML, CL-ML	A-4,A-6	0	100	100	95-100	90-100	20-35	3-15	14-27	Good	Improba-ble: access fines	Improba-ble: access fines	Good
Loess Out-wash Terrace	10-33	Silt loam	CL	A-6	0	100	100	95-100	90-100	25-40	15-25	22-35				
	33-62	Clay loam silt loam	ML,SC,	A-2,A-4	0-5	90-100	85-100	60-95	30-90	20-40	3-15	18-30				
	62-80	Stratified sandy loam to silt loam	SM,SC, ML,CL	A-2,A-4	0-5	90-100	80-100	50-80	20-60	<25	3-10	5-20				

Appendix C (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification USCS	Classification AASHTO	Frag > 3in (%)	Percent Passing Sieve # #4	#10	#40	#200	LL (%)	PI (%)	Clay (%)	Rating of Predominant Soil Conditions: Roadfill	Sand	Gravel	Topsoil
Cincinnati																
Illinoian Ground Morraine (Till Plain)	0-7	Silt loam	ML,CL	A-4,A-6	0	100	100	90-100	80-100	25-40	3-16	15-25	Fair: low strength wetness	Improbable: excess fines	Improbable: excess fines	Fair: area recla small stones
	7-23	Silty clay loams	CL	A-6,A-4	0	95-100	90-100	90-100	70-100	25-40	8-15	22-35				
	23-80	loam, silt loam										24-35				
Crider	0-8	silt loam	ML,CL	A-4,A-6	0	100	95-100	90-100	85-100	25-35	4-12	15-27	Poor: low strength	Improbable excess fines	Improbable excess fines	Fair: too clay slope
limestone benches	8-37	Silt loam, silty clay loam	CL,ML, CL-ML	A-7,A-6 A-4	0	100	95-100	90-100	85-100	25-42	4-20	18-35				
	37-80	Silty clay, clay, silty clay loam	CL,CH	A-7,A-6	0-5	85-100	75-100	70-100	80-100	35-65	15-40	30-60				
Fairpoint	0-6	Shaly silt loam	CL,CL-ML,SC, GC	A-4,A-6, A-2	5-15	55-90	45-85	40-85	30-75	20-40	4-18	0-6	Poor: slope	Improbable: excess fines	Improbable: excess fines	Poor: small stone area slope
Sandstone-Shule (Wabash lowland) Plateau	6-60	Gravelly clay loam, very shaly silty clay loam	GC,CL, CL-ML, SC	A-4,A-6 A-7,A-2	15-30	55-75	25-65	20-65	15-60	25-50	4-24	6-60				
Hagerstown	0-13	Silt loam	CL,CL-ML	A-4,A-6 A-7	0-15	85-100	80-100	80-100	70-95	25-50	5-25		Poor: low strength	Improbable: excess fines	Improbable: excess fines	Poor: small stone slope
Loess on sandstone shale-limestone Plateau	13-60	Clay, silty clay, silty clay loam	CH,CL	A-7,A-6	0-5	85-100	80-100	75-100	75-95	30-70	15-40					

Appendix C (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification USCS	AASHTO	Frag > 3in (%)	Percent Passing Sieve # #4	#10	#40	#200	LL (%)	PI (%)	Clay (%)	Rating of Predominant Soil Conditions Roadfill	Sand	Gravel	Topsoil
Haymond	0-9	Silt loam	ML	A-4	0	100	100	90-100	80-90	27-36	4-10	10-18	Good	Improbable: excess fines	Improbable: excess fines	Good
Flood	9-59	Silt loam	ML	A-4	0	100	100	90-100	80-90	27-36	4-10	10-18				
Plain	59-70	Fine Sandy loam, Silt loam, loam	ML, SM	A-4	0	95-100	90-100	80-100	35-90	27-36	4-10	10-18				
Hosmer	0-8	Silt loam	ML, CL-ML, CL	A-4	0	100	100	90-100	70-90	<25	3-10	10-17	Fair: low strength wetness	Improbable: excess fines	Improbable: excess fines	Good
Loess on Lacustrine Plain	8-26	Silt loam, Silty Clay loam	CL, CL-ML, ML	A-4, A-6	0	100	100	90-100	70-95	25-35	5-15	24-30				
	26-80	Silt loam, Silty Clay	CL, CL-ML, ML	A-4, A-6	0	100	100	90-100	70-95	20-55	30	16-42				
Johnsburg	0-13	Silt loam	CL, ML	A-4, A-6	0	100	100	90-100	70-95	30-40	5-15	12-20	Fair: area reclaim low strength; thin layer	Improbable: excess fines	Improbable: excess fines	Fair: small stones
Loess on Lacustrine Plains	13-23	Silty Clay loam, Silt loam	CL	A-6, A-7	0	100	100	95-100	85-95	35-50	20-30	24-32				
	23-42	Loam, silt loam, Silty clay loam	CL, CL-ML	A-4, A-6	0-5	95-100	90-95	85-95	60-85	20-35	5-15	22-30				
	42-70	Loam, Sandy loam, Silt loam	CL, SC, CL-ML, SM-SC	A-4, A-6	5-10	90-95	85-90	60-90	35-70	20-30	5-15	14-20				
Markland	0-5	Silt loam	CL, CL-ML	A-4, A-6	0	100	100	90-100	70-90	25-35	5-15	20-27	Poor: low strength; shrink, swell	Improbable: excess fines	Improbable: excess fines	Poor: thin layer
Lacustrine Plain and Terrace	5-35	Silty clay, Clay, Silty clay loam	CL, CH	A-7	0	100	100	95-100	90-95	45-60	19-32	40-55				
	35-60	Stratified Clay to silty clay loam	CL, CH, ML, MH	A-7	0	100	100	90-100	75-95	40-55	15-25	30-50				

Appendix C (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification USCS	Classification AASHTO	Frag > 3in (%)	Percent Passing Sieve # #4	#10	#40	#200	LL (%)	PI (%)	Clay (%)	Rating of Predominant Soil Conditions Roadfill	Sand	Gravel	Topsoil
Markland	0-3	Silty Clay loam	CL	A-6,A-7	0	100	100	95-100	85-95	30-45	10-20	28-40				
Lacustrine Plain and Terrace	3-27	Silty Clay, Clay, Silty clay loam	CL,CH	A-7	0	100	100	95-100	90-95	45-60	19-32	40-55	Poor: low strength; shrink, swell	Improb-able: excess fines	Improb-able: excess fines	Poor: thin layer
	27-60	Stratified clay to Silty clay loam	CL,CH ML, MH	A-7	0	100	100	90-100	75-95	40-55	15-25	35-50				
Martins-ville	0-9	Loam	CL,CL-ML,ML	A-4	0	100	85-100	75-100	65-90	<25	3-8	8-20	Good	Improb-able: excess fines	Improb-able: excess fines	Fair: small stones
Alluvial Terrace (Sand and Gravel)	9-58	Fine Sandy loam, Loam Sandy Clay loam	SM-SC, CL-ML, CL-SC	A-2,A-4, A-6	0	95-100	85-100	55-95	30-75	20-30	5-11	15-25				
	58-80	Stratified Sand to fine sand	SM,SM-SC,CL-ML	A-4,A-2-4,	0	95-100	85-100	45-95	10-75	<25	NP-8	2-20				
McGary	0-7	Silty Clay loam	CL	A-6,A-7	0	100	100	90-100	70-95	30-45	15-25	27-40	Poor: low strength	Improb-able: excess fines	Improb-able: excess fines	Poor: thin layer
Lacustrine Terrace	7-60	Silty Clay, Silty Clay loam	CL,CH	A-7	0	100	100	95-100	90-100	46-58	24-32	35-50				
Negley	0-9	Silt loam, Loam	ML,CL-ML,CL	A-4,A-6	0	85-100	75-100	70-90	55-85	25-40	4-15	12-27	Poor: slope	Proba-ble	Proba-ble	Poor: small stones, slope
Outwash and Terrace	9-80	Loam, Clay loam, Gravelly sandy loam	SM,ML	A-4,A-2, A-6,A-7	0-5	70-95	50-90	35-80	20-60	25-45	3-17	18-35				
Newark	0-13	Silt loam	ML,CL, CL-ML	A-4	0	95-100	90-100	80-100	55-95	<25	NP-10	7-27	Poor: low strength	Improb-able: excess fines	Improb-able: excess fines	Poor: wetness
Flood Plain	13-32	Silt loam, Silty Clay loam	ML,CL, CL-ML	A-4,A-6, A-7	0	95-100	90-100	85-100	70-98	22-42	3-20	18-35				
	32-60	Silt loam, Silty Clay loam	ML,CL, CL-ML	A-4,A-6, A-7	0-3	75-100	70-100	65-100	55-95	22-42	5-23	12-40				

Appendix C (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification		Frag > 3in (%)	Percent Passing Sieve #				LL (%)	PI (%)	Clay (%)	Rating of Predominant Soil Conditions			
			USCS	AASHTO		#4	#10	#40	#200				Roadfill	Sand	Gravel	Topsoil
Nolin	0-11	Silt loam	ML, CL, CL-ML	A-4, A-6	0	100	95-100	90-100	80-100	25-40	5-18	12-35	Poor: low strength	Improb-able: excess fines	Improb-able: excess fines	Good
Flood Plain	11-70	Silt loam, Silty Clay loam	ML, CL, CL-ML	A-4, A-6, A-7	0	100	95-100	85-100	75-100	25-46	5-23	18-35				
Parke	0-6	Silt loam	CL-ML, CL	A-4, A-6	0	100	100	90-100	70-100	20-35	7-15	18-27	Good	Improb-able: excess fines	Improb-able: excess fines	Fair: small stones
Loess on Outwash Terrace	6-34	Silty Clay loam, silt loam	CL	A-6, A-4	0	95-100	95-100	90-100	80-100	25-40	7-15	22-32				
	34-80	Sandy clay loam, Sandy	SC, CL	A-2, A-6, A-4	0-3	90-100	85-95	55-90	30-60	7-15	18-30					
	0-12	Silt loam	CL, CL-ML	A-4, A-6	0	100	100	85-100	65-100	20-30	5-15	15-26				
Alluvial Terrace (Low Terraces)	12-24	Silt loam, Silty Clay loam	CL	A-6	0	100	100	90-100	70-100	25-40	10-20	25-35	Fair: wetness	Improb-able: excess fines	Improb-able: excess fines	Good
	24-58	Silt loam, Silty Clay loam	CL, CL-ML	A-4, A-6	0	100	100	88-98	65-90	25-35	5-15	22-30				
	58-70	Stratified fine Saody loam to silty clay loam	CL, CL-ML	A-4, A-6	0	100	100	80-95	50-85	20-40	5-15	20-34				
	0-14	Silt loam	CL	A-4, A-6	0	100	100	90-100	80-95	25-35	8-15	18-27				
Loess on Outwash Terrace	14-42	Silty Clay loam, Silt loam	CL	A-6, A-7	0	100	95-100	85-100	80-90	30-45	10-25	22-35	Good	Improb-able: excess fines	Improb-able: excess fines	Good
	42-80	Loam, Silt loam, Sandy clay loam	CL, SC	A-6, A-2-6	0	80-100	70-100	60-95	30-80	20-35	10-20	18-35				
Wakeland	0-7	Silt loam	ML	A-4	0	100	100	90-100	80-90	27-36	4-10	10-17	Fair: low strength, wetness	Improb-able: excess fines	Improb-able: excess fines	Good
Flood Plain	7-60	Silt loam	ML	A-4	0	100	100	90-100	80-90	27-36	4-10	10-17				

Appendix C (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification USCS	Classification AASHTO	Frag > 3in (%)	Percent Passing Sieve # #4	#10	#40	#200	LL (%)	PI (%)	Clay (%)	Rating of Predominant Soil Conditions Roadfill	Sand	Gravel	Topsoil
Wellston	0-6	Silt loam	ML	A-4	0	95-100	90-100	85-100	70-95	25-35	3-10	13-27	Fair:	Improb-able: excess fines	Improb-able: excess fines	Poor: small stones
Sandstone Shale Plateau	6-48	Silt loam, Silty Clay loam	CL, CL-ML	A-6, A-4	0-5	75-100	70-100	60-95	60-90	25-40	5-20	18-35				
Gilpin	0-4	Channery Silt loam	GC, SC	A-2, A-4	0-30	50-90	45-85	35-75	30-70	20-40	4-15	15-27	Poor: thin layer Slope	Improb-able: excess fines	Improb-able: excess fines	Poor: Slope, small stones
Sandstone Shale Plateau	4-30	Channery Silt loam, Shaly silt loam, Channery Silty clay loam	GC, SC, CL, CL-ML	A-2, A-4, A-6	0-30	50-95	45-90	35-85	30-80	20-40	4-15	18-35				
	30-36	Unweathered bedrock	--	--	--	--	--	--	--	--	--	15-35				
Wellston	0-12	Silt loam	ML	A-4	0	95-100	90-100	85-100	70-95	25-35	3-10	13-27	Fair: depth to rock, low strength	Improb-able: excess fines	Improb-able: excess fines	Poor: small stones, area reclaim
Sandstone Shale Plateau	12-36	Silt loam, Silty Clay loam	CL, CL-ML	A-6, A-4	0-5	75-100	70-100	60-95	60-90	25-40	5-20	18-35				
	36-60	Silt loam, Loam, Channery loam	CL-ML, CL, SC, SM-SC	A-4, A-6	0-10	65-90	65-90	60-90	40-65	20-35	5-15	15-30				
Ebal	0-5	Silt loam	CL-ML, CL	A-4, A-6	0	95-100	95-100	85-100	70-90	25-35	5-15	20-28	Poor: low strength, Shrink swell	Improb-able: excess fines	Improb-able: excess fines	Poor: small stones
Sandstone Shale Plateau	5-24	Channery Silty clay, Very channery clay	CL, CH GC	A-7	3-15	60-70	50-70	45-70	40-65	40-55	20-30	38-50				
	24-70	Clay	CH	A-7	0-3	95-100	70-100	55-100	55-95	60-75	35-45	55-70				
Wellston	0-6	Silt loam	ML	A-4	0	95-100	90-100	85-100	70-95	25-35	3-10	13-27	Fair: depth to rock, low strength	Improb-able: excess fines	Improb-able: excess fines	Poor: small stones area reclaim
Sandstone Shale Plateau	6-49	Silt loam, Silty Clay loam	CL, CL-ML	A-6, A-4	0-5	75-100	70-100	60-95	60-90	25-40	5-20	18-35				
	49-60	Silt loam, Loam, Channery loam	CL-ML, CL, SC, SM-SC	A-4, A-6	0-10	65-90	65-90	60-90	40-65	20-35	5-15	13-50				

Appendix C (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification USCS	Classification AASHTO	Frag > 3in (%)	Percent Passing Sieve # #4	#10	#40	#200	LL (%)	PI (%)	Clay (%)	Rating of Predominant Soil Conditions Roadfill	Sand	Gravel	Topsoil
Gilpin	0-4	Channery Silt loam	GC,SC, CL,CL-ML	A-2,A-4 A-6	0-30	50-90	45-85	35-75	30-70	20-40	4-15	15-27				
Sandstone Shale Plateau	4-31	Channery loam, Shaly Silty clay loam, Silty clay loam	GC,SC, CL,CL-ML	A-2,A-4, A-6	0-30	50-95	45-90	35-85	30-80	20-40	4-15	18-35	Poor: thin layer	Improb-able: excess fines	Improb-able: excess fines	Poor: Slope, small stones
	31-39	Channery loam, very channery silt loam, very shaly silty clay loam	GC,GM-GC	A-1,A-2, A-4,A-6	0-35	25-55	20-50	15-45	15-40	20-40	4-15	15-35				
	39	Unweathered bedrock	--	--	--	--	--	--	--	--	--	--				
Wellston	0-1	Silt loam	ML	A-4	0	95-100	90-100	85-100	70-95	25-35	3-10	13-27				
Sandstone Shale Plateau	1-39	Silt loam, silty clay loam	CL,CL-ML	A-6,A-4	0-5	75-100	70-100	60-95	60-90	25-40	5-20	18-35	Fair: depth to bedrock, low strength	Improb-able: excess fines	Improb-able: excess fines	Poor: small stones, area reclaim slope
	39-55	Silt loam, Loam, channery loam	CL-ML, CL,SC, SM-SC	A-4,A-6	0-10	65-90	65-90	60-90	40-65	20-35	5-15	15-30				
	55	Unweathered bedrock	--	--	--	--	--	--	--	--	--	--				
Wilbur	0-6	Silt loam	ML,CL-ML	A-4	0	100	100	90-100	70-90	<25	3-7	10-17	Fair:	Improb-able: excess fines	Improb-able: excess fines	
Flood Plain	6-60	Silt loam	ML,CL-ML	A-4	0	100	100									
Wirt	0-6	Fine sandy loam	SM,SM-SC,ML, CL-ML	A-4	0	95-100	90-100	65-85	35-55	<25	NP-6	8-16	Good	Improb-able: excess fines	Improb-able: excess fines	Good
Flood Plain	6-60	Silt loam, Loam, Fine sandy loam	CL-ML, ML	A-4	0	95-100	90-100	75-100	55-90	<25	3-7	10-18				

Appendix C (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification		Frag > 3in (%)	Percent Passing Sieve #				LL (%)	PI (%)	Clay (%)	Rating of Predominant Soil Conditions			
			USCS	AASHTO		#4	#10	#40	#200				Roadfill	Sand	Gravel	Topsoil
Zanesville	0-5	Silt loam	CL-ML, CL,ML	A-4,A-6	0	95-100	95-100	90-100	80-100	25-40	4-15	12-27	Severe: low strength	Improb-able: excess fines	Improb-able: excess fines	Poor: area reclaim
Sandstone Shale Plateau	5-30	Silt loam, silty clay loam	CL,CL-ML	A-4,A-6	0	95-100	95-100	90-100	80-100	25-40	5-20	18-35				
	30-44	Silt loam, silty clay loam	ML,CL CL-ML	A-4,A-6	0-3	90-100	85-100	80-100	60-100	20-40	2-20	18-33				
	44-60	Sandy clay loam, Clay loam, channery loam	SC,CL, SM,GM	A-6,A-4, A-2 A-1-B	0-10	65-100	50-100	40-100	20-85	20-40	2-20	20-24				
Zanesville	0-1	Silt loam	CL-ML, CL,ML	A-4,A-6	0	95-100	95-100	90-100	80-100	25-40	4-15	12-27				
Sandstone Shale Plateau	1-20	Silt loam, Silty clay loam	CL,CL-ML	A-4,A-6	0	95-100	95-100	90-100	80-100	25-40	5-20	18-35	Severe: low strength	Improb-able: excess fines	Improb-able: excess fines	Poor: area reclaim
	20-39	Silt loam, Silty clay loam	ML,CL, CL-ML	A-4,A-6	0-3	90-100	85-100	80-100	60-100	20-40	2-20	18-33				
	39-70	Sandy clay loam, Clay loam, channery loam	SC,CL, SM,GM	A-6,A-4, A-2, A-1-B	0-10	65-100	50-100	40-100	20-85	20-40	2-20	20-24				
Zanesville	0-1	Silt loam	CL-ML, CL,ML	A-4,A-6	0	95-100	95-100	90-100	80-100	25-40	4-15	12-27				
Sandstone Shale Plateau	1-30	Silt loam, Silty clay loam	CL,CL-ML	A-4,A-6	0	95-100	95-100	90-100	80-100	25-40	5-20	18-35	Severe: low strength	Improb-able: excess fines	Improb-able: excess fines	Poor: area reclaim
	30-48	Silt loam, Silty clay loam	ML,CL, CL-ML	A-4,A-6	0-3	90-100	85-100	80-100	60-100	20-40	2-20	18-33				
	48-55	Sandy clay loam, Clay loam	SC,CL, SM,GM	A-6,A-4, A-2 A-1-B	0-10	65-100	50-100	40-100	20-85	20-40	2-20	20-40				
	55	Unweathered bedrock	--	--	--	--	--	--	--	--	--	--				

Appendix C (Con't)

Soil Name and Map Symbol	Depth (in)	USDA Text	Classification		Frag > 3in (%)	Percent Passing Sieve #				LL (%)	PI (%)	Clay (%)	Rating of Predominant Soil Conditions			
			USCS	AASHTO		#4	#10	#40	#200				Roadfill	Sand	Gravel	Topsoil
Zipp Lacustrine Plain	0-10	Silty clay loam	CL	A-6,A-7	0	100	100	95-100	90-95	35-50	15-25	22-40	Poor: low strength, wetness, shrink-swell	Improbable: excess fines	Improbable: excess fines	Poor: wetness
	10-47	Silty clay	CL,CH	A-7	0	100	100	95-100	90-95	45-60	25-35	40-55				
	47-60	Silty clay	CL,CH	A-7	0	100	100	90-100	75-95	45-60	25-35	36-55				

APPENDIX D

Appendix D

Soil and Water Features (4)
For Martin County, Indiana

Agricultural Soil Name & Symbol	Landform Type & Material	Hydrologic Group	Flooding			High Water Table			Bedrock		Potential Frost Action	Risk of Corrosion	
			Frequency	Duration	Months	Depth ft.	Kind	Months	Depth In	Hardness		Uncoated Steel	Concrete
Abscota	Flood Plain	A	Frequent	Brief	Mar-Jun	> 6.0	---	---	> 60	---	Low	Low	Low
Alvin,	Wind blown Sand on Terrace/Incipient Sand Dune	B	None	---	---	> 6.0	---	---	> 60	---	Moderate	Low	High
Chelsea	Sand Dune	A	None	---	---	> 6.0	---	---	> 60	---	Low	Low	Low
Bartle	Benchlike flats, Lacustrine	D	None	---	---	1.0-2.0	Perched	Jan-Apr	> 60	---	High	High	High
Birds	Flood Plain	C/D	Frequent	Long	Mar-Jun	+.5-1.0	Apparent	Mar-Jun	> 60	---	High	High	Moderate
Bonnie	Flood Plain	C/D	Frequent	Brief to Long	Jan-Jun	+.5-1.0	Apparent	Jan-Jun	> 60	---	High	High	High
Brunside	Flood Plain	B	Occasional	Brief	Mar-Jun	3.0-5.0	Apparent	Feb-Jun	40-65	Hard	Moderate	Low	High
Camden	Loess on Outwash Terrace	B	None	---	---	> 6.0	---	---	> 60	---	High	Low	Moderate
Cincinnati	Illinoian Ground Moraine	C	None	---	---	2.5-4.0	Perched	Jan-Apr	> 60	---	High	Moderate	High
Crider	Limestone Benches	B	None	---	---	> 6.0	---	---	> 60	---	---	Moderate	Moderate

Appendix D Continued

Agricultural Soil Name & Symbol	Landform Type & Material	Hydrologic Group	Flooding			High Water Table			Bedrock		Potential Frost Action	Risk of Corrosion	
			Frequency	Duration	Months	Depth ft.	Kind	Months	Depth In	Hardness		Uncoated Steel	Concrete
Fairpoint	Limestone	C	None	---	---	> 6.0	---	---	> 60	---	Moderate	High	Moderate
Hagerstown	Loess on Sandstone-Shale Plateau	C	None	---	---	> 6.0	---	---	> 60	Hard	Moderate	Moderate	Low
Haymond	Flood Plain	B	Frequent	Brief	Jan-May	> 6.0	---	---	> 60	---	High	Low	Low
Hosmer	Loess on Lacustrine Plain	C	None	---	---	2.5-3.0	Perched	Mar-Apr	> 60	---	High	Moderate	High
Johnsburg	Loess on Lacustrine Plain	D	None	---	---	1.0-3.0	Perched	Jan-Apr	48-72	Soft	High	High	High
Markland	Lacustrine Plain/ Terrace	C	None	---	---	3.0-6.0	Perched	Mar-Apr	> 60	---	Moderate	High	Moderate
Martinsville	Alluvial Terrace	B	None	---	---	> 6.0	---	---	> 60	---	Moderate	Moderate	Moderate
McGary	Lacustrine Plain	C	Rare	---	---	1.0-3.0	Apparent	Jan-Apr	> 60	---	Moderate	High	Low
Negley	Outwash Plain and Terrace	B	None	---	---	> 6.0	---	---	> 60	---	Moderate	Low	High
Newark	Flood Plain	C	Frequent	Brief	Jan-Apr	0.5-1.5	Apparent	Dec-May	> 60	---	High	High	Low

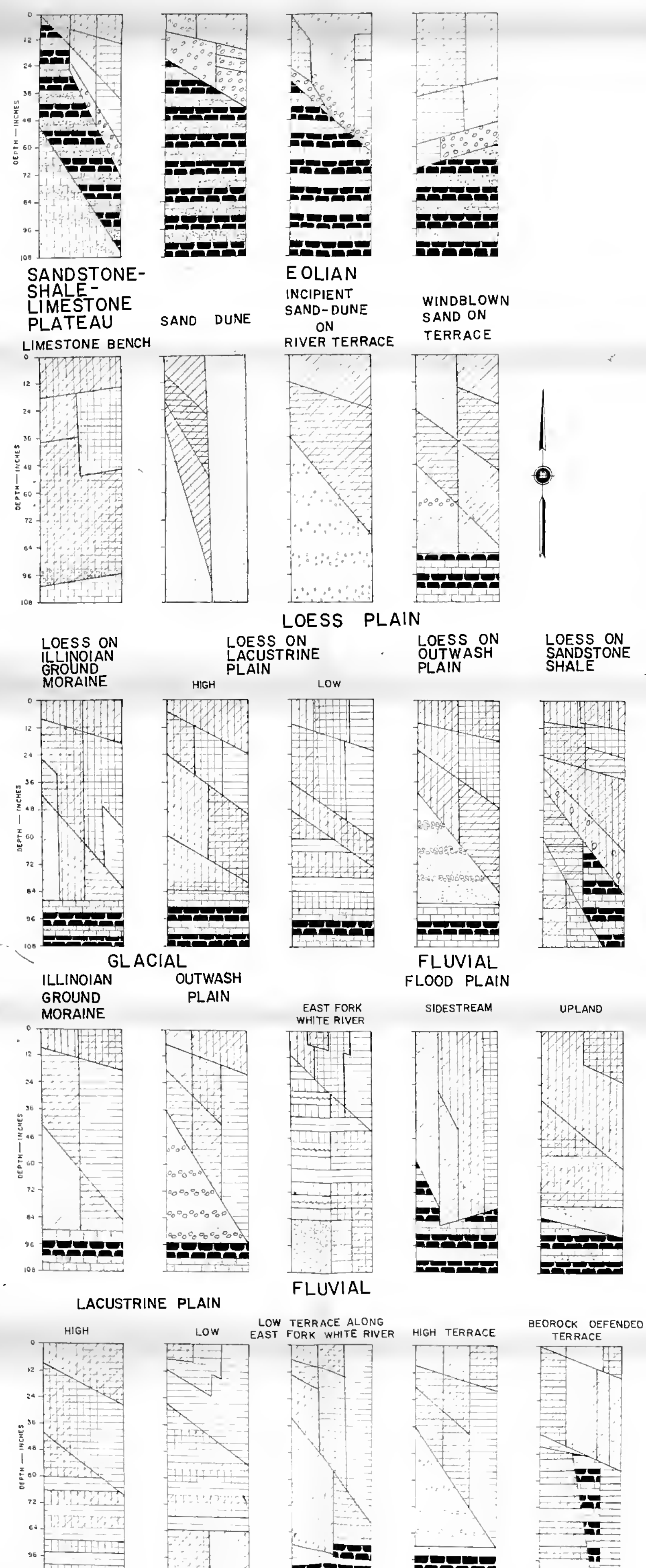
Appendix D Continued

Agricultural Soil Name & Symbol	Landform Type & Material	Hydrologic Group	Flooding			High Water Table			Bedrock		Potential Frost Action	Risk of Corrosion	
			Frequency	Duration	Months	Depth ft.	Kind	Months	Depth In	Hardness		Uncoated Steel	Concrete
Nolin	Flood Plain	B	Frequent	Brief to Long	Feb-May	3.0-6.0	Apparent	Feb-Mar	> 60	---	---	Low	Moderate
Parke	Loess on Outwash Terrace	B	None	---	---	> 6.0	---	---	> 60	---	High	Moderate	High
Pekin	Lacustrine Plain	C	None	---	---	2.0-6.0	Apparent	Mar-May	> 60	---	High	High	Moderate
Pike	Loess on Outwash Plain	B	None	---	---	> 6.0	---	---	> 60	---	High	Low	High
Wakeland	Flood Plain	C	Frequent	Brief to Long	Jan-May	1.0-3.0	Apparent	Jan-Apr	> 60	---	High	High	Low
Wellston	Sandstone-Shale Plateau	B	None	---	---	> 6.0	---	---	> 40	Hard	High	Moderate	High
Berks	Sandstone Shale Plateau	C	None	---	---	> 6.0	---	---	20-40	Soft	Low	Low	High
Gilpin	Sandstone Shale Plateau	C	None	---	---	> 6.0	---	---	20-40	Soft	Moderate	Low	High

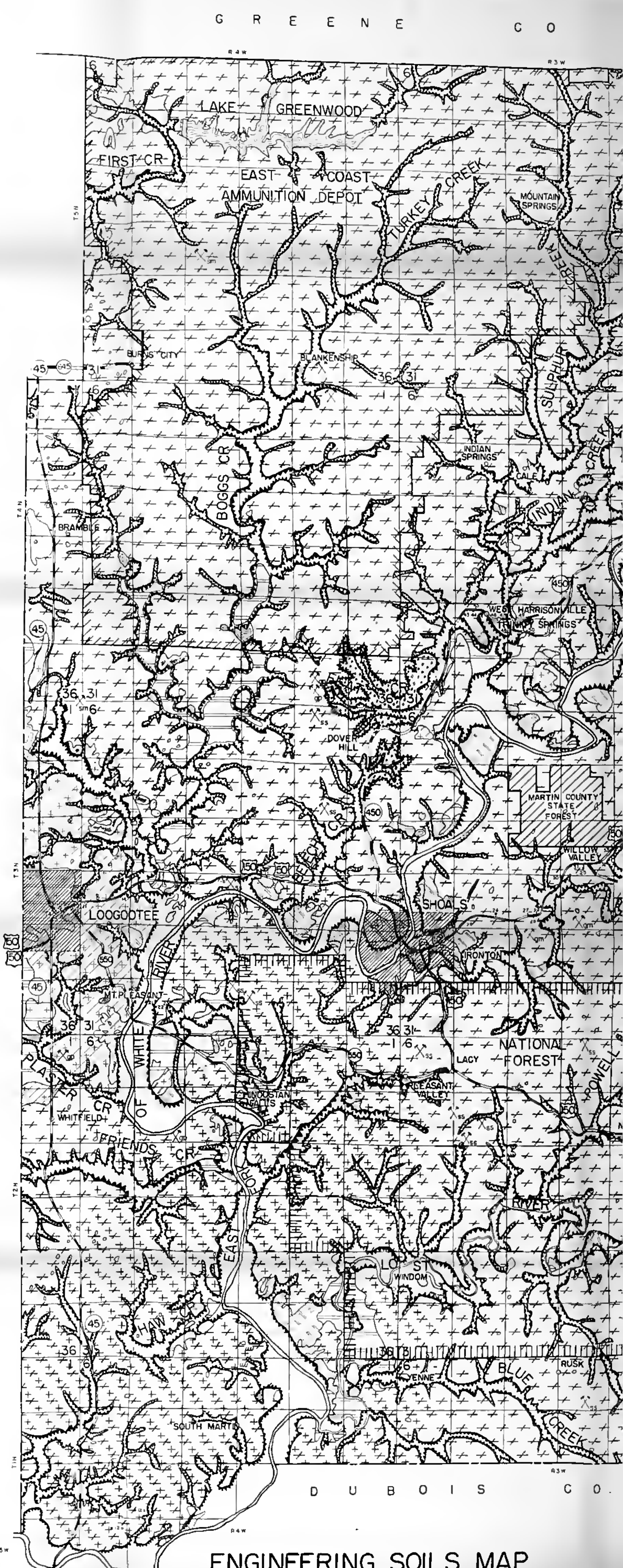
Appendix D Continued

Agricultural Soil Name & Symbol	Landform Type & Material	Hydrologic Group	Flooding			High Water Table			Bedrock		Potential Frost Action	Risk of Corrosion	
			Frequency	Duration	Months	Depth ft.	Kind	Months	Depth In	Hardness		Uncoated Steel	Concrete
Wellstoo	Sandstone Shale Plateau	B	None	---	---	> 6.0	---	---	> 40	Hard	High	Moderate	High
Edal	Sandstone Shale Plateau	B	None	---	---	3.0-6.0	Perched	Nov-Mar	50-80	Soft	Moderate	High	High
Wellston	Sandstone Shale Plateau	B	None	---	---	> 6.0	---	---	> 40	Hard	High	Moderate	High
Gilpin	Sandstone Shale Plateau	C	None	---	---	> 6.0	Perched	---	20-40	Soft	Moderate	Low	High
Wellstoo	Sandstone Shale Plateau	B	None	---	---	> 6.0	---	---	> 40	Hard	High	Moderate	High
Udorthents Wilbur	Flood Plain	B	Frequent	Brief	Oct-Jan	1.5-3.0	Apparent	Mar-Apr	> 60	---	High	Moderate	Moderate
Wirt	Flood Plain	B	Frequent	Brief	Nov-Jun	> 6.0	---	---	> 60	---	Moderate	Low	Moderate
Zanesville	Sandstone Shale Plateau	C	None	---	---	2.0-3.0	Perched	Dec-Apr	> 40	Hard	---	Moderate	High
Zanesville	Sandstooe Shale Plateau	C	None	---	---	2.0-3.0	Perched	Dec-Apr	> 40	Hard	---	Moderate	High
Udorthents	Lacustrine Plain	D	Rare	---	---	1.5-1.0	Apparent	Dec-May	> 60	---	Moderate	High	Low

GENERAL SOIL PROFILES



PREPARED UNDER THE SUPERVISION OF: I O OKONKWO AND R D MILES



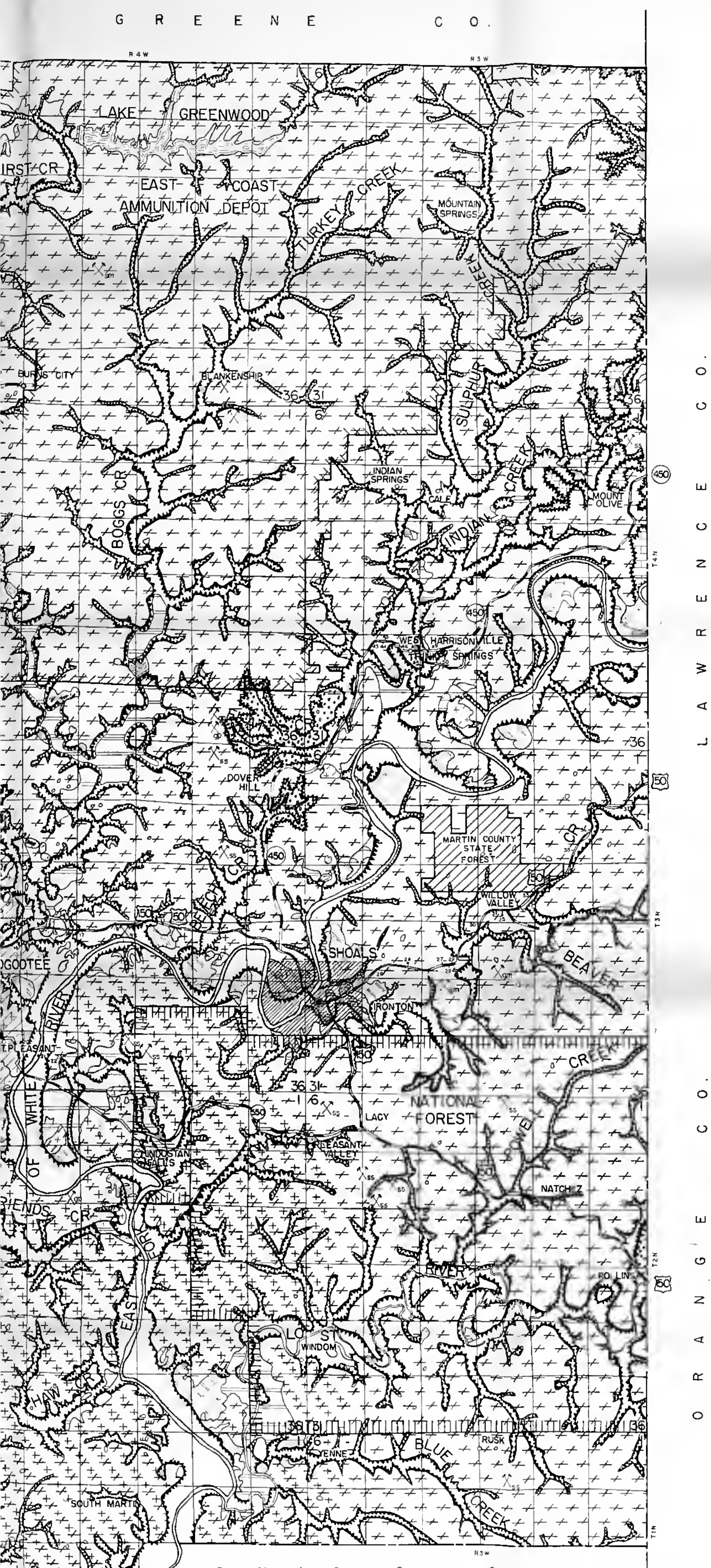
ENGINEERING SOILS MAP

MARTIN COUNTY

INDIANA

PREPARED FROM
1940 AAA AERIAL PHOTOGRAPHS
BY
JOINT HIGHWAY RESEARCH PROJECT
AT
PURDUE UNIVERSITY

SCALE OF MILES



ENGINEERING SOILS MAP

MARTIN COUNTY

INDIANA

PREPARED FROM
1940 AAA AERIAL PHOTOGRAPHS
BY
JOINT HIGHWAY RESEARCH PROJECT
AT
PURDUE UNIVERSITY

SCALE OF MILES

1 3/4 1/2 1/4 0 1 2 3 4

POLYCONIC PROJECTION

LEGEND

PARENT MATERIALS

(GROUPED ACCORDING TO LAND FORM AND ORIGIN)

- LOESS PLAIN
- LOESS ON LACUSTRINE PLAIN
- LOESS ON ILLINOIAN GROUND MORAINE
- LOESS ON SANDSTONE-SHALE PLATEAU
- LOESS ON OUTWASH PLAIN
- SAND DUNE
- RIVER TERRACE INCIPIENT SAND DUNE
- WINDBLOWN SANO ON TERRACE
- LIMESTONE BENCH
- SANDSTONE-SHALE BENCH
- ILLINOIAN GROUND MORAINE
- OUTWASH PLAIN
- LACUSTRINE PLAIN
- LIMESTONE PLAIN
- INTERBEDDED SANDSTONE-SHALE PLATEAU
- BEDROCK DEFENDED TERRACE
- FLOOD PLAIN

MISCELLANEOUS

- STRIP MINE
- GRAVEL PIT
- LAKE, POND OR RESERVOIR
- DAM
- NATIONAL PURCHASE BOUNDARY
- URBAN AREA
- HIGHLY ORGANIC TOP SOIL
- MARSH AND SWAMP
- BORING SITES

TEXTURAL SYMBOLS

(SUPERIMPOSED ON PARENT MATERIAL TO SHOW RELATIVE COMPOSITION)

- GRAVEL
- SAND
- SILT
- CLAY

TEXTURAL SYMBOLS FOR SOIL PROFILES

- GRAVEL
- SAND
- STONY
- SHALE
- SILT
- CLAY
- LOAM
- SANDSTONE

DRAWN BY X. O. WANG AND Y. WU

COVER DESIGN BY ALDO GIORGINI